Being a compilation from the work of various agricultural workers on and off the field on diverse subjects, these Memoirs may have a certain inevitable lack of continuity and unevenness in quality. The work is also necessarily incomplete, as all knowledge and the application of such knowledge can never be complete. It is, however, a record of much useful work done by the Madras Agricultural Department and has been presented in a form that may help both the technical reader and the layman. It is hoped that these contributions to knowledge made by a number of agricultural workers, will offer a field from which more radiant knowledge will be developed as a beacon for the future of agricultural prosperity.

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APPENDICES.

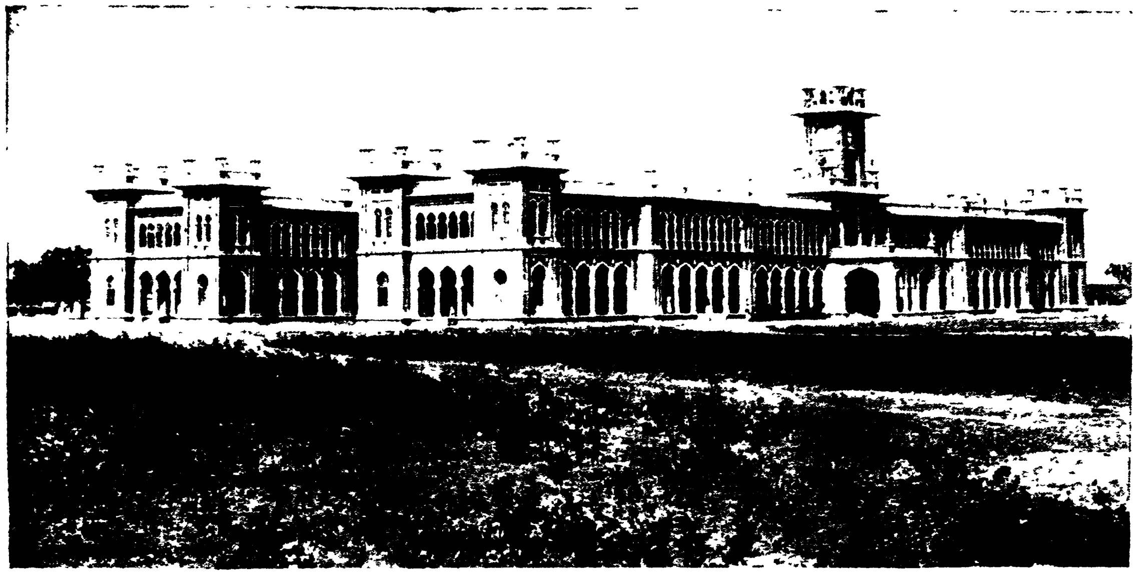


Plate 1 (a).—The Agricultural Research Institute, Coimbatore. [*Frontispiece*]

Plate 1 (b).—The Agricultural College (Freeman Building), Coimbatore. [*Frontispiece*]

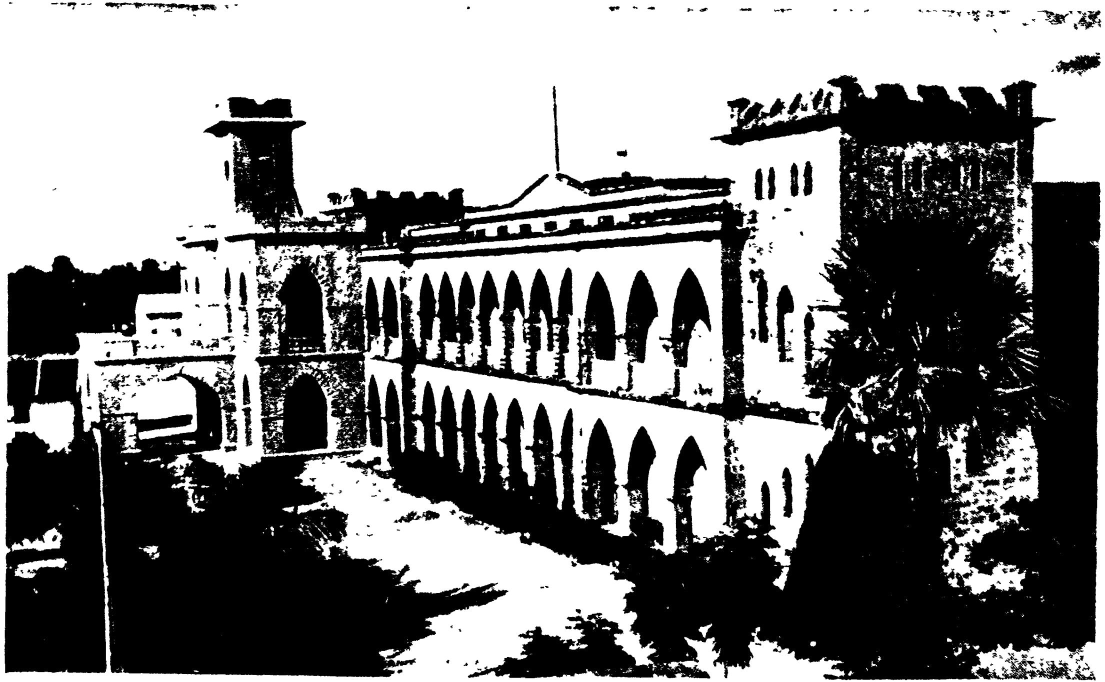


Plate 2.—The Agricultural College, Bapatla. [*Frontispiece*]

MEMOIRS OF THE DEPARTMENT OF AGRICULTURE, MADRAS.

CHAPTER I.

HISTORY OF THE MADRAS AGRICULTURAL DEPARTMENT.

The need for an Agricultural Department—Stages in the development of agriculture from primitive to modern times—Lines of improvement—The origin, growth and organization of the Madras Agricultural Department Research and Research Stations—Propaganda and demonstration—Agricultural Education—Marketing.

Before narrating the history and development of agriculture in this State, it may be as well to consider why an Agricultural Department is necessary for a State.

In the development of agriculture three distinct stages can be distinguished. The first is the most primitive method of clearing and burning an area of forest, and raising one or two crops in the clearing and then moving on to repeat the operation elsewhere, when the soil fertility gets exhausted. This form of cultivation, practised by wandering tribes and hillmen, was very wasteful and only poor crops could be obtained. As population increased and communities were established to settle in definite places and form villages, this primitive type of shifting cultivation gave place to a more settled form of cultivation—the second stage. Even in this stage, the cultivator relied on the forest for replenishing the fertility of his lands, either directly by applying the leaves of the forest or indirectly, by grazing the animals in the forests and applying their manure to his fields. The third stage was reached when cultivation extended beyond the proximity of the forests and large acres were cultivated in the plains to meet the growing needs of an increasing population. The fertility of these lands had to be maintained, so that crops could be grown for the needs of the population every year and for the requirements of commerce and industry. Crop rotation had to be practised, irrigation resources developed and new methods of cultivation introduced or the existing ones modified to suit varying conditions of soil, climate and rainfall. The incidence of pests and diseases had to be studied, and the loss caused by them and by adverse seasonal conditions controlled and minimized. It was at this stage of agriculture that the need for an Agricultural Department was felt, to study the various problems of agriculture and to introduce new methods and improvements in the existing agricultural practices. The problems to be solved by the Department of Agriculture in Madras

have been many and various, but the most important were : (1) the supply of improved seeds and plants of different crops giving higher yields and better quality to suit various conditions, (2) the recommendation of suitable manures to different crops and soils, (3) the combating of crop pests and diseases, (4) the introduction of better methods of cultivation and crop rotations, (5) the supply of improved agricultural implements, (6) soil conservation, (7) the cultivation of fruit crops and special plantation crops, and (8) improved methods of marketing of agricultural produce so as to give better returns to the producer.

Agricultural occupation, which is the back bone of the country can hold its own against other industries, and feed successfully a great and growing population, only if farming is done by progressive methods based on scientific research and the proper application of the results. It was with this purpose, that the Agricultural Department was reorganized in 1906 and was later developed to meet the growing needs of the farmer.

It may be useful to mention briefly the earlier attempts to introduce agricultural improvements in the State, before the department was started. The first recorded attempt, is the introduction of a variety of foreign cotton from Mauritius in the year 1790, the relic of which is the Bourbon cotton. In 1835, the Agri-Horticultural Society was founded in Madras to promote agricultural improvements. Certain experiments were conducted by the Superintendent of Cotton Operations, between 1842 to 1853, on New Orleans, Sea Island and Bourbon cottons. In 1854, an agricultural exhibition and cattle show were arranged and prizes were awarded.

Practical interest in agricultural development was awakened as early as 1863, by the then Governor, who drew attention to the prevalent practice of continuous cropping, the deficiency of cattle manure and its misuse as fuel, the defective implements, the lack of trees, the poor cattle, and the want of accurate knowledge and statistics in the State. As a consequence, orders were placed in England for a steam plough, steel harrows and cultivators, seed drills, threshing and winnowing machines and water lifts. An area of 350 acres of land at Saidapet, owned by the Nawab of Carnatic, was taken over by Government for conducting trials with the foreign implements and machines. A committee was appointed to test artificial manures and improved systems of agriculture. Since no remarkable progress was made even after seven years, the Board of Revenue took over control of the Saidapet Farm in 1871. A Superintendent of the farm appointed in 1868, became the Assistant to the Commissioner for Agriculture, for general statistical and agricultural work.

In 1876, a complete and high class public Agricultural College was established at Saidapet. This was the beginning of agricultural education in the State. The control of the College was transferred to the Director of Public Instruction in 1884, and this

arrangement continued up to 1905. The main work done during this period, was the tabulation of village statistics, analysis of famine records and enquiries on agricultural economics.

The Indian Famine Commission of 1880, investigated the question of practical improvements in agriculture and the steps to be taken by the State to encourage the industry. The Commission, among other things, recommended the revival of Agricultural Departments by the Government of India and the simultaneous formation of Agricultural Departments in all States. In Madras, a separate Agricultural Department was organized in 1881–82, with a Director of Settlement and Agriculture, designated as the Commissioner for Revenue Settlement, Land Records and Agriculture. Six years later, in 1888, a committee was appointed to make a comprehensive enquiry into the constitution and operations of the Agricultural Department. This committee strongly recommended research, experiments and organization and the need for agricultural farms in the districts. Action on this recommendation was taken only in 1897, when the sugarcane crop in the Godavari area was damaged by red-rot. To tackle the disease, an Economic Botanist was appointed in 1898. This may be said to be the beginning of agricultural research in Madras. Besides the work on the Samalkota Sugarcane Farm from 1902, an agricultural farm was opened at Palur in South Arcot district in 1905, for research on groundnut, and another in Taliparamba in 1905, to investigate the 'pollu' disease of pepper. For work on cotton, farms were started in 1901, at Hagari in Bellary district and at Koilpatti in Tirunelveli district. In 1889, an Agricultural Chemist was specially appointed by the Government of India to report on the expansion of work in agricultural chemistry and to effect improvements in agriculture. Based on his report, which was presented in 1891, a re-orientation was given to the Agricultural Department in this State in line with the developmental policy laid down by the then Viceroy. As a consequence, a whole-time Director of Agriculture was appointed in 1906, to work under the Board of Revenue, and an Agricultural College and Research Institute was established in 1907 at Coimbatore. The Saidapet Farm was closed and the students were transferred to the newly equipped college at Coimbatore. The control of the Director of Public Instruction over the Agricultural College, also ceased with this change. This new department consisted, besides the Director of Agriculture, an Economic Botanist, an Agricultural Chemist and two Deputy Directors (North and South) for district work. From these small beginnings the work of the department has expanded in different directions with specialized staff as indicated hereunder.

Propaganda and district work.—Eight regional Deputy Directors of Agriculture with a District Agricultural Officer for each district, and an Agricultural Demonstrator for each taluk, a Plant Protection Wing with one Entomologist and one Mycologist each, for the north and south zones and five Seed Development Officers.

Research Officers.—Crop Specialists for rice, cotton, millets, pulses, sugarcane, oil-seeds and fruits with Assistant Specialists in important district centres and Research Assistants. In addition to these, a Cardamom Specialist and a Pepper Specialist have also been recently appointed. The other specialists are, the Lecturing and systematic Botanist, the Agricultural Chemist, the Mycologist, the Entomologist and the Agricultural Research Engineer. Two Cyto-Geneticists, two Plant Physiologists, a Bio-chemist for fruit products and an Agricultural Meteorologist have also been appointed. For the development of marketing, there is a State Marketing Officer with four regional Marketing Officers and Marketing Assistants. Other officers are (*a*) fourteen Superintendents in charge of Agricultural Research Stations, (*b*) two Assistant Agricultural Engineers for tractor workshops and another for contour-bunding work.

The history of expansion in research and development work is given below in broad outline.

Agricultural research and experiments.—The research work of the Agricultural Department may be divided into the fundamental and applied work done by the Specialists at the Research Institute at Coimbatore, and the supplementary work done in the several Agricultural Research Stations in the districts, to test the application of Coimbatore results to varying local conditions. All fundamental work connected with the evolution of new strains for different crops or the introduction of improved cultural and manurial practices, or the treatments against crop pests and diseases, originated from the Specialists in the Agricultural Research Institute and this procedure is still being continued. As the work expanded, however, the need for carrying out experiments in the actual centres of production arose, and regional stations for crops were started : for rice in Aduthurai, Maruteru and Pattambi, for cotton in Hagari and Koilpatti, for groundnut in Tindivanam and for sugarcane at Anakapalli and Gudiyattam under the Specialists. These stations under the control of the Specialists at Coimbatore helped to further intensify the research programme on these crops in the districts. At the same time, a third type of agricultural stations developed, devoted mainly to local agricultural study of the several crops in particular areas. These were under the control of the Deputy Directors of Agriculture and were helped, where necessary, by a staff trained by the Crop Specialists. Besides experimental work on a number of local agricultural problems, these stations were also engaged in the trial and multiplication of improved seed, manurial investigations, research into local cultural methods and practices and the testing of new varieties and plants.

The development of research with a well-equipped research section for each branch of agricultural science under a Specialist started when an Economic Botanist was appointed for plant-breeding work in 1902. A separate Chemistry section was formed in 1909, at Coimbatore, to investigate into problems on soils, manures, waters, food-stuffs, agricultural products and processes and to

function in an advisory capacity. Work on plant diseases was transferred to a separate section in 1910 under a Mycologist, for research on plant diseases in view of the growing importance of such diseases as bud-rot on palmyra, red-rot on sugarcane and 'Mahali' on arecanut. The need for urgent remedial measures against many insect pests attacking cultivated crops was recognized and a separate section under an Entomologist was opened in 1912 for this purpose and also for promoting bee-culture and sericulture.

It was felt that a single Economic Botanist was not adequate for the requirements of such important crops as rice, cotton, millets, oil-seeds, etc., which were grown in large areas and demanded special attention on account of their major importance to the State. The work of the Economic Botanist was divided into two sections, one for research and the other for teaching. The research work was further intensified by the appointment of an Economic Botanist for rice in 1913 and of a Sugarcane Specialist in 1912.

The Paddy Breeding Station was started at Coimbatore in 1913, and the work of genetic investigations on the plant and evolution of improved strains received greater impetus with the opening up of sub-stations at Aduthurai in Tanjore district (1922), Maruteru in West Godavari district (1925), Pattambi in Malabar district (1927), Berhampur in Ganjam district (1932) (since transferred to Orissa), Ambasamudram in Tirunelveli district (1937), Buchireddipalem in Nellore district (1937), Tirurkuppam in Chingleput district (1942) and Mangalore in South Kanara district (1942). Besides fundamental work on the rice plant, the paddy section has evolved strains suited to the major rice growing tracts, comprising an area of ten and a half million acres in the State. Three Seed Development Officers are in charge of distribution of improved seeds.

Cotton was the next crop to receive attention. A Cotton Specialist was appointed in 1921 and he followed up the earlier work done on the crop since 1909. The Cotton Breeding Station was started at Coimbatore in 1922 and the work which was started with Cambodia, Karunganni and Uppam was extended into the districts when the Koilpatti Farm was expanded to cater to the needs of the 'Tinnies' areas, the Hagari Farm for 'Western' cotton and the Nandyal Farm for white 'Northerns.' Even from the earlier years, improved strains were evolved for each of the major commercial varieties. The Indian Central Cotton Committee financed many schemes for expansion and improvement of cotton work as in Uppam, Cocanadas, the Mungari scheme at Adoni, the Cambodia cotton scheme at Palur and the white Northerns. New strains were evolved and a special variety called 'Uganda' was introduced. This, a cross between Cambodia and South African Uganda, was capable of spinning counts of 50s, and was the finest commercial cotton so far produced in India. Research work has also been extended to the evolution of long staple types in all important areas and the introduction of Sea

Island cotton in the West Coast. A Cotton Extension Officer and three Assistant Cotton Extension Officers were appointed in 1950 to do intensive work in the districts on all items of propaganda, including supply of cotton seeds, with the object of increasing the production of cotton in the State so as to achieve self-sufficiency.

A separate research section for millets was started in 1921 at Coimbatore to cater to the needs of those large areas where these food crops of the poor are grown. The Millets Breeding Station was opened in 1923, beginning with the more important millets :—sorghum, *bajra*, ragi and tenai. Supplementary work was done at Hagari and Nandyal from 1931 and at Guntur from 1932. Recently, (1948) sub-stations have been opened in Tirupattur (North Arcot), Narasapatam (South Visakhapatnam), Ongole (Guntur) and Ariyalur (Tiruchirapalli) for research on a regional basis, since millets show a high degree of susceptibility to changes in environmental and soil factors. Strains have been evolved to suit irrigated and rainfed crops and for the large commercial areas like the *Pachajonna* of Nandyal and Guntur, the *Tellajonna* of Bellary and the *Periyamanjal* and *Irungu* sorghum areas of the south. High yielding types of ragi and tenai are under distribution and improved varieties of Punjab *bajra* have been introduced In order to meet the expanding need for seed distribution, two Seed Development Officers were recently appointed for distribution of improved millet strains.

It was only in 1930 that an Oil Seed section was opened under a Specialist at Coimbatore. Research was started with groundnut, gingelly and castor and the work on groundnut was later intensified in the Tindivanam Agricultural station in South Arcot district, a major district for this crop. Fundamental studies on these crops have been taken up and useful information on the cultivation aspects and manuring has been obtained. High yielding strains have been produced in varieties of groundnut, both bunch and spreading, gingelly, castor and they are under distribution. Work on coconut, originally carried out by the Deputy Director of Agriculture was transferred to the Oil Seeds Specialist. Cultural and manurial experiments and study of varieties and hybrids are in progress at the Coconut Research Stations at Kasargod and Nileshwar in South Kanara district besides fundamental research on the crop. The Coconut Research Station, Kasargod, has been handed over to the Indian Central Coconut Committee in 1947 for developing into a Central Coconut Research Institute under the Committee. For supplying selected coconut seedlings, nurseries have been opened in eight centres in this State, viz., Nileshwar (South Kanara), Pattambi (South Malabar), Pattukottai (Tanjore), Tindivanam (South Arcot), Samalkota (East Godavari), Maruteru (West Godavari), Anakapalle (Visakhapatnam), and Coimbatore Central Farm. Improved seeds are under distribution and experiments are being conducted on manuring, mixed cropping, and hybridisation and on the storage of oil seeds.

As already stated, research on sugarcane was the earliest to start in this State in 1902, primarily to investigation the 'red rot' disease that was prevalent on the then cultivated canes called 'noble canes'. A Sugarcane Breeding Station was started in 1912 at Coimbatore, and the work expanded by the introduction of hybrid types raised from seed; this gave a wide range of material, from which, varieties suited to the variety of conditions and tracts over the whole of India could be selected. The improved canes originally evolved, mainly catered to the large sugarcane areas of Northern India where a thin type of cane was required. On account of the importance of the sugarcane work at Coimbatore to the vast sugarcane tracts outside the State, the Government of India took over control of the Sugarcane Breeding Station, Coimbatore, from the year 1925. With the appointment of a second Sugarcane Expert, the thick canes of Madras also received more attention and practically all the area in Madras is now under the improved canes that were evolved at Coimbatore. Work in Madras developed in line with the recommendations of the Indian Sugar Committee of 1920. Sub-stations were opened in Anakapalle (1913) and at Gudiyatham (1936) helped by funds sanctioned by the Indian Council of Agricultural Research. Supplementary research in varietal and agronomical studies are being continued at Palur in South Arcot and Samalkota in East Godavari district. A Sugarcane Specialist for Madras was appointed in 1918 with headquarters at Anakapalle, where the activities of sugarcane research were expanded by the appointment with the financial aid of the Indian Central Sugarcane Committee of a Chemist, a Mycologist and a Physiologist. During 1949, under the Madras Sugar Factories Control Bill, liaison farms for cane improvement work, have been started in the factory areas at Samalkota, Hospet, Nellikuppam and Pugalur. While the Central Research Station at Coimbatore continues to do the work of evolution of new types of hybrid canes, trials of improved types, field studies, work on pests and diseases and chemical and physiological investigations are conducted by the Sugarcane section at Anakapalle.

A separate section was established for Agricultural Engineering at Coimbatore in 1928 with a wholetime Research Engineer in accordance with the recommendation in 1926, of the Royal Commission on Agriculture. Work was devoted to the study and improvement of mechanical farm equipment, including implements, irrigation installations and oil engines. An up-to-date workshop was constructed in 1931, and the section designed improved types of seed drills, *guntakas*, hand hoes, ploughs and mechanical graders for fruits, potatoes and eggs. With the increased activities consequent on the Grow More Food campaign, the work of the section expanded. The manufacture of agricultural implements through fabricators, introduction of pumping sets and tractors, and the opening up of new lands through tractor ploughs and bull dozers were taken up. Recently, Agricultural Engineers have been appointed for contour bunding in Ceded Districts and for tractor workshops at Bapatla and Coimbatore.

An impetus to fruit growing in Madras, was given by the appointment of a Superintendent for the Koduru Fruit Research Station started in 1935. Work was first devoted to the improvement of mangoes and the local sathgudi oranges by propagation of improved plants, disease resistant types, off-season bearers, and introduction of proper and efficient orchard practices. These studies had financial aid from the Indian Council of Agricultural Research. In order to co-ordinate and centralise all fruit research work, a Fruit Specialist was appointed from 1941. The three fruit stations in the Nilgiris, viz., Coonoor, Burliar and Kallar were also placed under his control. Supplementary work on the evolution and distribution of improved plants and seedlings is being done at Coimbatore, Araku, Anakapalle, Guntur, Wynad and Taliparamba. A research station, devoted exclusively for work on bananas, was opened at Aduthurai (Tanjore district) in 1949. Recently, model fruit stations were opened in Madurai, East Godavari, South Kanara and other districts. A diploma course in Horticulture and a certificate course were instituted in 1948. The Fruit Specialist's headquarters was transferred from Koduru to Madras in 1948 and then to Coimbatore in 1950.

The Pulses section was established in 1943 and with financial aid by the Indian Council of Agricultural Research a Pulses Specialist was appointed on a temporary basis. He took over from the Cotton Specialist and the Millets Specialist, work and materials on pulses, handled till then, by them. More intensive work was started from 1943 and multiplication of selected varieties was done in cowpea, horsegram, bengalgram and lablab. Three sub-stations were opened at Coimbatore, Dharmapuri (Salem district) and Vizianagaram (Visakhapatnam) for the isolation of high yielding strains of pulses resistant to disease. In order to increase the area under pulses, a scheme was worked out in 1944–45 for purchase and free distribution of blackgram, greengram and redgram.

The Livestock section was started in the year 1916 as a part of the Agricultural Department. In 1938 the section was transferred to the Animal Husbandry Department. The work was under a Deputy Director of Livestock with headquarters at the Hosur Cattle Farm which was opened in 1924. Previously, a cattle breeding station had been opened at Chintaldevi in Nellore district for improvement of the Ongole breed of cattle, and another farm was opened at Guntur in 1923 for the breeding of buffaloes. The work of this section was devoted to the introduction of better breeds of milkers like the Scindi breed, the crossing of Ayrshire with Scindi and Sahewal for producing improved milkers and the introduction of pedigree stock for improving the major local breeds of Kangayam, Ongole and the Hallikar. The earlier work on sheep at Hagari and Bantanahal stations was devoted to evolving from a type of black faced vigorous rams a pure breed bearing white wool. The Livestock section also helped to distribute breeds of imported

poultry like the White Leghorns and Rhode Island Reds and indigenous improved types like the Chittagong and Tellicherry.

As already mentioned, the Agricultural Chemistry branch was one of the earliest research sections to be started at Coimbatore in 1909. The earlier work commenced with the investigations on soils, manures, foodstuffs, etc., but as the work expanded, the following lines of work were undertaken in an intensive form: (1) Soil Surveys, (2) Soil Physics, (3) Physical Chemistry, (4) Plant Nutrition, (5) Bacteriology, (6) Animal Nutrition and (7) Manufacture of Malt. Investigations were also made on the manurial value of different kinds of organic and inorganic manures, and their effect in different doses on the production and quality of various crops. The nutritive value of crops raised with different manures was one of the lines of investigation; the chemistry of the decomposition of green manures under different conditions, was another line of study. In addition to these, certain agro-industries like the manufacture of cream jaggery and of malt foods were also developed. During the last world war, the malt factory was established to supply malt extract with shark liver oil to the army, and the manufacture is being continued for supplies to the hospitals and public. An animal nutrition wing was added to this section from 1928, to investigate into the feeding requirements of different breeds of animals and the value of different fodders and concentrates. This work which was financed by the Indian Council of Agricultural Research, was closed after a ten-year scheme was concluded. The original work of soil surveys conducted in the Tanjore, Godavari, Krishna and Malabar districts were later extended and elaborated on other areas proposed for irrigation projects like the Lower Bhavani and Thungabhadra projects. Recently, a Plant Physiologist and Research staff have also been added to the section.

The Mycology section was created in 1910 primary to investigate such diseases as the Palmyra bud-rot, and the '*mahali*' disease of arecanuts. Later, the work was extended to deal with all important crop diseases like the smut on sorghum, the 'blast' on rice, the mosaic and the red rot of sugarcane, the mildew on grapes and the wilt disease of groundnut. In order to meet the increasing demands from the ryots, for quick facilities to take up the successful remedial measures evolved against plant diseases, two Plant Protection Officers for Mycology have recently been appointed in the districts with an extension staff. The Mycology section has also developed methods for the preparation of 'food yeast' and the manufacture of 'ergot' of rye. Special wings of the section are now working for control of rice diseases, for the preparation of ergot in Ootacamund and for the investigation of the 'Pollu' disease of pepper in Taliparamba.

The Entomology section was started in 1912. Preliminary work was devoted to studying the life histories of insect pests on crops and the remedial measures to be taken against them. Among the important lines of work first taken up by the section, may be

mentioned the control of the pink-boll worm and the stem weevil of cotton; later, the research was extended to control such important crop pests as the swarming caterpillar, the stem borer and the bug on rice, the borers on sugarcane, the thrips on chillies, the mango hopper, the fruit-sucking month, the caterpillar and the beetle on the coconut, the hairy caterpillar and the 'surul' on groundnut and the pests of stored products. Besides protective and remedial measures, biological methods of control by insect parasites were also introduced in some cases. Bee-keeping and sericulture were developed and a number of beed-colonies introduced in the districts. The effects of different insecticides were investigated. Two Plant Protection Officers as for Mycology were appointed in 1948, to extend the application of remedial measures into the districts.

To help in the work of protection of crops against insects and diseases, two legislative measures were enacted, namely, (1) the Destructive Insects and Pests Act of 1914—A quarantine measure to prevent the introduction into the country of insect pests and (2) the Madras Pests and Diseases Act of 1919, to prevent their spread in the State. The latter Act was applied against insect pests of cambodia cotton, the hairy caterpillar attacking groundnut and bajra, the bud-rot on palmyra and even against the water-hyacinth, a pernicious weed.

A separate Marketing section was created in Madras in 1934, in line with an All-India plan, to improve the conditions of marketing and ensure better returns to the producer. An intensive enquiry was conducted on the marketing of certain commodities with funds sanctioned by the Indian Council of Agricultural Research and development work was started, based on these surveys. Regulated markets providing fair and open sales, where market changes are controlled, were established under the Madras Commercial Crops Market Act of 1933, for cotton at Tirupur in 1936, and extended in 1939 for groundnut in South Arcot, cotton in Adoni and Nandyal, tobacco in Guntur and Vijayavada and further in 1949–50 for cotton and groundnut in Bellary, Coimbatore and Anantapur districts and coconut and its products and arecanut in Malabar and South Kanara. Under the Agricultural Produce Grading and Marking Act of India, 1937, grade standards were introduced in Madras for tobacco, rice, oranges, mangoes, eggs, edible oil and ghee, to help both in internal and international trade. Among other items of work done by the section are the supply of marketing intelligence, standardization of weights and measures, fixation of standards of quality, conditions of warehousing and storage, co-operative marketing and helping growers and the trade to find markets for their produce internally and in export trade. To extend the scope of its work more intimately into the districts, the marketing section was reorganised in June 1948, with regional Assistant Marketing Officers in charge of a group of districts with headquarters at Kakinada, Coimbatore, Cuddapah and Tiruchirapalli.

AGRICULTURAL RESEARCH STATIONS.

As already mentioned, the Agricultural Research Stations established by the department were intended to investigate the suitability and application to local conditions of the results of research obtained by the specialists. During the past fifty years, 58 research stations have been opened, some of them designed for the purpose of studying local farming problems and some for the study of particular crops. A list of the research stations so far opened, of which 42 are now in existence, is given below :—

Agricultural Research Stations in Madras.

Serial number and name of district.	Name of stations.	Year in which opened.	Year in which closed.	Primary object or crops dealt with.
(1)	(2)	(3)	(4)	(5)
1 East Godavari ..	Samalkota	1902	..	Sugarcane and paddy.
2 South Arcot ..	Palur	1905	..	Groundnut, sugarcane and paddy.
3 Malabar ..	Taliparamba	1905	.	Originally for pepper.
4 Coimbatore ..	Central farm ..	1906	.	Mixed farm attached to Research Institute and Agricultural College.
5 Bellary ..	Hagari	1906		Cotton, millets and dry farming practices.
6 Tirunelveli ..	Koilpatti	1901		Cotton and millets.
7 Kurnool ..	Nandyal ..	1906	..	Do.
8 Anantapur ..	Hindupur	1901	1911	Agave plantation.
9 Chingleput ..	Attur . .	1906	1908	Paddy
10 Krishna ..	Vijayavada . .	1908	1912	Do.
11 Coimbatore .	Sugarcane breeding station.	1912	1925	Sugarcane. Transferred to the control of Government of India.
12 Visakhapatnam ..	Anakapalle	1913	.	Sugarcane and paddy.
13 Kurnool ..	Sirvel	1914	1922	To study agricultural problems connected with Velugod project
14 Tanjore ..	Manganallur ..	1912	1922	Paddy
15 Coimbatore ..	Paddy breeding station.	1913	.	Do
16 Bellary . ..	Bantanahal .	1916	1922	Sheep rearing and seed farm.
17 South Kanara ..	Nileshwar No. I (Pilicode)	1916	.	Coconuts.
18 Do.	Do. No. II.	1916	..	Coconuts.
19 Do.	Do. No. III.	1916	.	Coconuts.
20 Do. ..	Kasaragod .	1916	..	Do. Transferred to Government of India.
21 Nilgiris	Nanjanad ..	1917	.	Potatoes
22 Coimbatore ..	Anaimalai ..	1917	1923	Cambodia cotton.
23 South Arcot .	Palakuppam ..	1926	1935	Groundnut
24 Nellore ..	Ongole cattle breeding station, Chintaldevi	1918	1932	Ongole breed of cattle.
25 North Arcot ..	Gudiyatham ..	1918 1936	1923	Sugarcane, do.
26 Nilgiris ..	Pomological Station, Coonoor	1919	..	....
27 Do.	Fruit Station, Kallar.	1919	.	Hill fruits.
28 Do.	Do. Burliar	1919	..	Hill fruits.
29 Coimbatore ..	Cotton breeding station.	1922	..	Cotton.
30 Guntur	Guntur	1922	..	Millets, tobacco and chillies.
31 Tanjore	Aduthurai	1922	..	Paddy.
32 Guntur	Buffaloe breeding station.	1923	1932	....
33 Coimbatore ..	Millet breeding stations.	1923	..	Millets.
34 Salem	Hosur cattle farm ..	1924	1938	....
35 West Godavari ..	Maruteru	1925	..	Paddy.
36 Malabar	Pattambi .. .	1927		Do.
37 Coimbatore ..	Betal-wine station, Vallalur.	1926	1929	Investigation of betelvine diseases.
38 Old Ganjam district.	Berhampore (now in Orrisa State)	1932	1937	Paddy.
39 South Arcot ..	Tindivanam ..	1936	..	Groundnuts.
40 Tanjore	Pattukkottai ..	1935	..	Paddy.
41 Cuddapah	Fruit Research Station, Kodur.	1935	..	Fruits of the plains.
42 Bellary	Siruguppa	1937	..	Irrigation experiments for Tungabhadra Project.

Serial number and name of district.	Name of stations.	Year in which opened.	Year in which closed.	Primary object or crops dealt with.
(1)	(2)	(3)	(4)	(5)
43 Tirunelveli ..	Ambasamudram ..	1937	..	Paddy.
44 Nellore	Buchireddipalayam.	1937	..	Do.
45 Chingleput	Tirurkuppam ..	1942	..	Do.
46 South Kanara ..	Mangalore	1942	..	Do.
47 Salem	Pulses sub-station, Dharmapuri.	1943	..	Pulses.
48 Visakhapatnam ..	Pulses Sub-station, Vijayanagaram.	1943	..	Do.
49 Guntur	Madhavaram farm, Agricultural College, Bapatla.	1945	1950	College farm on lease. New farm opened in 1950.
50 Visakhapatnam ..	Arakku Valley ..	1945	..	Land improvement.
51 Malabar	Wynad ..	1945	..	Land improvement.
52 Nilgiris	Agricultural Research Station, Wellington.	1943	1949	English vegetables.
53 Chittoor	Kalahasti ..	1926	..	Demonstration farm.
54 Visakhapatnam ..	Narasapatnam ..	1948	..	Regional research stations for millets.
55 Guntur	Ongole	1948	..	Regional research stations for millets.
56 North Arcot ..	Tiruppattur ..	1948	..	Regional research stations for millets.
57 Tiruchirappalli ..	Ariyalur	1948	..	Regional research stations for millets.

PROPAGANDA AND DEMONSTRATION.

The research work done at Coimbatore and in the regional stations by the Crop Specialists is only the first step. When the suggested improvements are found applicable to any local area or crop, the work of spreading them to the cultivators in villages is entrusted to the district staff consisting of Agricultural Demonstrators, under the guidance of District Agricultural Officers and Deputy Directors. The propaganda methods adopted by the district staff fall under the following heads:—

(1) Propaganda in the villages accompanied where possible, by demonstration in ryots' fields.

(2) Publicity through departmental publications, villagers' calendar, journals, press notes, radio talks, posters, etc.

(3) Exhibitions and shows.

(4) Contact with ryots through village and taluk agricultural associations.

The nature and extent of activities in these and other lines of extension service, depended on the kind of the improvement, and the local conditions and are described in detail elsewhere in this book. Experience has shown that the best way of spreading improvements is by actual demonstration of the suggested methods on the fields belonging to the cultivators themselves. The ryots are then able to see the improvement under their own conditions and satisfy themselves about the advantages of the methods recommended for adoption.

The officer-in-charge of agriculture for each taluk is the Agricultural Demonstrator. Formerly one Demonstrator was in charge of two or three taluks but now the department has one for each

taluk, assisted by a staff of fieldmen and demonstration maistris. The fieldmen are trained by the department and are now provided at the rate of one for every two or three firkas, to supervise the work of trained maistris who have local experience and who are employed at about one for each firka. Depots have been provided at the rate of one or two per taluk to stock, for sale, and agricultural requirements like improved seeds, manures, implements, etc. The Demonstrators work under District Agricultural Officers who work in close co-operation with the Revenue Department, and are also attached to the Collectors of the district from the year 1941. To control the work of the District Agricultural Officers, Deputy Directors of Agriculture have been appointed for groups of districts, called circles. Their number has been varying. Between 1906 and 1914 there were only two circles, north and south, with headquarters at Bellary and Tiruchirappalli. From 1914 a central circle was added at St. Thomas Mount. In 1916, the circles were increased from three to seven, with Assistant Directors of Agriculture for every two or three districts, and a separate Deputy Director, one for livestock and another for the planting districts. Between 1921 and 1928, there were eight circles, but this number was reduced to three in 1938, and to two in 1941, as a measure of retrenchment. During 1941, the number of Assistant Directors was increased to provide an officer for each district re-named as District Agricultural Officers from 1941. During the war period the number of Deputy Directors was again raised to eight. The Deputy Directors have also control over the agricultural stations in the district. At present (1950) there are eight circles with headquarters as follows :—

(1) Visakhapatnam (North and South Visakhapatnam),

(2) Eluru (East and West Godavari and Krishna),

(3) Guntur (Guntur, Kurnool and Nellore),

(4) Cuddapah (Cuddapah, Bellary, Anantapur and Chittoor),

(5) Tanjore (South Arcot, Tanjore and Tiruchirappalli),

(6) Madurai (Madurai, Ramanathapuram and Tirunelveli),

(7) Vellore (North Arcot, Salem and Chingleput), and

(8) Coimbatore (South Kanara, Malabar, Coimbatore and Nilgiris).

During the war, when imports of rice from Burma and the Far East stopped, there was an urgent need to increase food production to meet the requirements of the State, and several schemes in the Grow More Food campaign were started for the purpose. The department was therefore further expanded and State Trading Schemes were taken up for supply of artificial manures, oil-cakes and iron and steel to the ryots. From the year 1943, certain schemes, under Post-war Reconstruction were also taken up for execution. Special staff was also employed for seed development work and for plant protection.

CHAPTER 2.

CROP IMPROVEMENT.

History of crop improvement—Methods and technique—Selection—Hybridization—Cytological studies—Hormones—Vernalization—Other factors—Statistics in crop improvement—Organization for the supply of pure seed.

Plants and mankind.—Swift, the famous English satirist, aptly said that " whoever could make two ears of corn or two blades of grass grow upon a spot of land where only one grew before, would deserve better of mankind and do more essential service to his country than the whole race of politicians put together ". Man has intimately associated himself with plants from time immemorial and has been continuously exploiting all the natural resources of plants for selfish ends. He has, in addition, hastened up by artificial methods, many processes, to imitate which Nature would ordinarily have taken many decades. To-day, he has a wealth of food crops, commercial crops, fruit crops, forage crops, green manure crops, building timbers and medicinal plants at his disposal, to meet his wants. Adverse conditions set up by nature like famine, floods, frost, gale, pests and diseases as well as unfavourable international relations like war and monetary exchange have given further impetus to maximise crop production and to make a country self-sufficient. In all these cases, plant selection and improvements in general agronomic practices have played a vital role in increasing the crop yields. Classical examples are (*a*) sugar beet and sweet lupdin in Europe whose evolution was necessitated by war conditions and (*b*) disease resistant potato varieties evolved as a result of potato famine in Europe caused by the fungal disease, *Phytophthora infestans.*

History of crop improvement.—Ever since the inception of life, both plants and animals were being subject to constant natural selection and only the fittest survived. As a result of this age-long process, multitudes of living forms have developed. Man who came into the picture only recently, depended for his existence on what nature could give him, like nuts, fruits and flesh. With the gradual increase of human population, competition was set up and man began to exploit both animals and plants for his own use. As food from animals was not always assured, plants which answered the purpose equally well, were preferred, as an alternative. Thus, in addition to natural selection, human selection also gradually played a part in the evolution of plants and in the final establishment of agricultural crops. Wild plants were domesticated and plants producing quick and large yields were ' selected '. By such a domestication, the wild grasses gradually became the familiar

food crops like rice, wheat, sorghum, **bajra,** ragi and tenai extensively cultivated to-day. Other cultural methods like ploughing, harrowing and weeding were later adopted to grow better crops on the same fields. New crops like chilli, tobacco, groundnut, potato and maize were introduced by travellers and explorers through the trade routes from foreign countries.

Methods of crop improvement—Breeding.—Plant breeding is in most languages synonymous with the word 'selection' and, indeed, the principle of selection lies at the root of all systems of plant improvement. Some sort of selection has been practised, consciously or unconsciously, by plant cultivators since the very earliest times. The art of 'pollination' was known to the ancient Egyptians and was exercised in the case of date palm, where the best forms were chosen for furnishing the pollen. Even to-day, many vegetable growers and florists collect and preserve seed by carefully selecting each year the best and most sturdy plants as seed bearers and thus build up excellent types of vegetables and novel flower plants. In the case of crops too, a good number of local varieties are known in rice, cotton, sorghum and wheat which are raised by the cultivators from seed carefully selected. Plant breeders have taken advantage of the wide variations, met with in the various crops and have either isolated a number of promising strains by selection or synthesized new strains through hybridization. There is one other method of crop improvement, viz., 'Plant introduction' which has met with remarkable success in many countries. Outstanding examples are the American cotton in India and the soyabean in America. On account of such successful introductions, this item is figuring in all crop-breeding programmes. Breeding is both a science and an art and a thorough knowledge of the biological sciences is required for solving problems of crop improvement and plant introduction. The knowledge should cover (*a*) genetic and cytogenetic principles, (*b*) characteristics of the crop to be improved including its wild relatives; (*c*) information regarding the needs of the grower; (*d*) special technique required for the solution of particular problems; (*e*) nature of disease and pests and (*f*) principles of field-plot techniques.

The existence of a close relationship between the mode of reproduction of a crop and the methods of breeding has been well recognized and accepted. Crop plants may be placed in asexual or sexual group according to their mode of reproduction.

The most important crop plants belonging to the asexual group are potatoes, sugarcane, sweet potato, tapioca, pepper, cardamom and bananas. Many horticultural plants grown for ornamental purposes or for flowers also belong to this group. The majority of fruit plants like pineapples, mangoes, citrus, apples and jujube are propagated by asexual methods of grafting, cutting, layering, budding, planting tubers or bulbs. Although this is the normal method in commercial propagation, reproduction by sexual means has occurred in asexually propagated varieties at one time or other

in the history of their development. But sports or mutations are frequent in the vegetatively propagated plants and they serve as a valuable source of new and useful varieties. The methods of breeding the asexual group may be summarised broadly as follows :—(*a*) systematic survey of material, (*b*) improvement by clonal selection and (*c*) breeding plants normally propagated asexually by sexual methods.

Plants belonging to the sexual group may be subdivided into (1) naturally self-pollinated, (2) often cross-pollinated, (3) naturally cross-pollinated and (4) dioecious groups. The naturally self-pollinated groups show less than four per cent. of cross-pollination as in the case of barley, wheat, oats, tobacco, potatoes, rice, flax, peas, beans, soybeans, cow-pea, bengalgram and ragi. In the often cross-pollinated group though self-pollination is more frequent than cross-pollination, prevention of cross-pollination by suitable methods is necessary in maintaining the purity of the varieties. Crops belonging to this group are cotton, sorghum and redgram. A good number of important crop plants like maize, bajra, onion, mustard, cabbage, beetsugar and sunflower come under the naturally cross-pollinated group. This group is composed of plants having widely different modes of pollination. In the case of maize where cross-fertilization is the rule, seeds set freely when artificial self-pollination is practised. Cross-pollination is carried out in nature in this crop exclusively through the agency of wind. Then there are many plants adapted to insect pollination where cross-pollination under normal conditions is essential to seed production. In the same flower, the essential organs like stamens (the male portion of the flower) and the pistil (the female portion of the flower) may mature at different periods. In certain plants like cabbage, tobacco and potato where the self-pollen is sterile, cross-pollination is the rule. The important crop plants of the dioecious group are hemp, date, palmyra and spinach. In these cases it is necessary to select both male and female plants for determining the breeding value of particular parents.

The effects of self-pollination in the four groups mentioned above are different. In naturally self-pollinated crops, self-fertilisation leads rapidly to genetic purity of the line and the progeny of individual plants will breed true. Self-pollination does not lead to loss of vigour in the often cross-pollinated plants like cotton. There is a rapid reduction in vigour in the naturally cross-pollinated group of plants. The extent of reduction of vigour is not however the same in all lines.

Heterosis or hybrid vigour noticed in many plants was recorded even as early as the eighteenth century by Kolereuter. The first generation hybrid is invariably more vigorous than the parents. A clear understanding of this phenomenon was the outcome of genetic research undertaken on the study of the effects of self-fertilization in cross-pollinated plants. Hybrid vigour is of value both in understanding evolution and in its application to plant breeding

and various explanations have been formulated from time to time. Heterosis has been shown to be a phase of quantitative inheritance governed by the Mendelian principles. Recent physiological studies on heterosis have indicated that the hybrid approached the better parent in its measure of physiological efficiency. The manifestation of heterosis varies with the nature of hybrids and arises out of different causes. The hypothesis of the complementary action of growth genes is the most accepted genetic explanation. To the plant breeder the explanation offered by Jones on the basis of partial dominance of linked growth factors has served as a good working basis for crop improvement programmes. In India, heterosis has been studied on crops like maize, brinjal, *bajra*, cotton and rice. Heterosis has great commercial possibilities in the case of plants which can be propagated asexually. In maize, by crossing suitable high yielding parent lines, the yield of the first generation has been maximised to a considerable degree. Such exploitation of hybrid vigour on a commercial basis will be possible in crops bearing fruits having a very large number of seeds per fruit and where crossing on a mass scale will be easy and cheap through special technique.

The methods of breeding in sexually propagated plants are divided into (*a*) mass selection, (*b*) pedigree selection and (*c*) hybridization involving straight selection of recombinations, backcrossing, heterosis and convergent improvements.

The method of mass selection as now practised in self-pollinated crops is chiefly a matter of 'rogueing' (removal of all the 'off-types' from the main type which constitutes the bulk) or of selecting the best of the individual plants or heads from a commercial standard variety and sowing them '*en massed*' in a plot for seed purposes. This method is practised to a small extent even to this day in many countries. Since the improvement achieved is only of a temporary nature, selection should be practised every year to maintain the standard of the bulk. In cross-pollinated plants, mass selection is of great value as a means of selecting and developing types suited to particular environmental factors. '*Grim dalfalfa*' in Minnesota (U.S.A.) is a product of such mass selection.

More varieties of self-pollinated crops have been obtained by the pedigree method than by other methods. Most commercial varieties are mixtures of different biotypes, isolated by selection methods. They are the result of natural crossing, mutation or mechanical mixing. The theory of "pure line selection" was first put on a firm scientific basis by Johannsen. Since then, the isolation of pure lines has become the first step in all breeding programmes and crop improvement by other methods are considered only after the possibilities by pure line selection are exhausted. For all practical purposes, the pure line theory furnishes a sound basis for the isolation of types which differ appreciably in heritable characters but whose progenies in self-pollinated crops bred relatively true. Mutations do occur and minor mutations of non-defective type are fairly

frequent although not sufficiently large to be of major selection value. Outstanding improvements have been obtained in yield, in resistance to drought, pests, and diseases and in quality by the pure line method in India and abroad. Some of the best known illustrations of this method of selection in cross-pollinated crops are the ear-to-row selection practised within corn, increase of sugar content in sugar beet and improvement of potatoes and asparagus.

Although simple pure line selection method has made substantial contribution towards crop improvement, it will not be possible to progress further after a certain stage. The object of crossing is to combine in one variety the desirable characters of two or more lines, varieties or species. Occasionally, recombination of genetic factors leads to the production of new desirable characters not found in either of the parents. The first extensive studies on hybridization were made as early as 1760 by the botanist Kolreuter on tobacco.

Later, Knight Gartner and others studied crosses in various crops. After the end of the nineteenth century, a scientific way of using plant hybridization was discovered by the Austrian monk Gregor Mendel. He studied individual plant characters and placed his results on a definite factor basis. He found how the characters in plants and animals were passed on to the off-spring in the same or recombined forms. Although the laws of inheritance as understood to-day are much more complex than those presented by Mendel and although the expression of characters is dependent upon the interaction of many genetic factors, the results of his work have found very wide application. Professor Biffen in England was one of the first to realise that laws of heredity could be used in practical plant breeding. He developed a new strain of wheat called ' Little Joss ' combining the yellow rust resistance of Russian wheat and the quality of the English wheat. The Mendelian method with suitable modifications has been widely adopted in all later crop improvement programmes of all countries except possibly in Russia. In recent years, it has been enlarged to include breeding for resistance to pests, diseases, frost, drought or lodging and for improving the quality like protein, vitamin or enzyme contents. A good collection and study of all available material are necessary in hybridization programmes. Vavilov and his co-workers have demonstrated the value of expeditions for the collection of useful plant material—wild and cultivated—and for the study of their variability. Such expeditions for plant collections have been largely organised since then by all progressive countries. When sufficient knowledge is gathered on the value and utility of characters spotted in the collections, a programme of crossing with a definite purpose in view is drawn up. It is not always easy to make crosses and obtain successful hybrids. Hence in the crossing programme, it is very necessary to have a thorough knowledge of the modes of pollination, compatibility and various botanical aspects

of the crops. Among the several methods of breeding, self-pollinated crops through hybridization, the pedigree method, the bulk method, the back-cross method and the multiple cross method are finding wide application.

In the pedigree method, a cross is made between two selected parents and in the subsequent generations the individual plants are studied. A record containing the behaviour of the individual families through successive generations is maintained. When the progeny becomes pure for the various characters studied, the produce is bulked, and released as an improved type for distribution.

The bulk method consists of growing the material in bulk plots from second to sixth generation and selection applied from the sixth generation onwards.

The backcross method is used primarily when it is desired to transfer one or two simply inherited characters of the non-recurrent parent to the recurrent parent which is usually a highly improved variety or a cultivated type. In this method, the F1 is crossed again to one of the parents (recurrent parent), if necessary a number of times, in order that new types combining a majority of factors from the recurrent parent with few desirable genes from the other parent (non-recurrent) can be got. Back cross technique has been successfully applied in evolving melons resistant to mildew, rust resistant wheat, corn types with tender pericarp and blackarm resistant varieties of cotton. In interspecific hybridization of cotton, the back cross technique is of great value in overcoming not only the sterility barrier but also in the transferring of factors from Asiatic to the American cottons. A number of useful selections have been synthesised by crossing Asiatic and American cottons in India by applying this technique.

The method of multiple crosses was first suggested by Harland and Martini in 1940. If eight varieties are desired to be combined a series of bridging crosses are made as follows: a × b, c × d, e × f, g × h. In the second mating, the F1 plants will be crossed to produce double crosses (a × b) × (c × d); and (e × f) × (g × h). In this mating, the double crosses will again be combined as follows: [(a × b) × (c × d)] × [e × f) × (g × h)]. Since segregation takes place at the time when second and third matings are made, a large number of crosses have to be made at each stage. By this procedure, unusual combinations and exceptional segregates are obtained. After this crossing, a large population will have to be tested either by pedigree or bulk method. The method is now used with various modifications in the case of maize in America.

In recent years, a good amount of work has been done on assessing the combining ability of crosses. Not all crosses give promising results. Investigations made on maize show, that when two high-yielding lines are crossed, the first generation is vigorous and prolific and conversely when low-yielding lines are crossed, the hybrid gives only poor yields. The combining ability of the parents is therefore an important index in the planning of all crossing programmes.

Hybridization within the varieties of a species, may not always give sufficient scope for maximum crop improvement. It may be necessary to cross two different species of a genus or even two different genera of plant kingdom. Interspecific and intergeneric crosses have attracted the attention of various workers throughout the world, both from the point of plant breeding and of taxonomy. The characters present in the allied wild species, are often of great value, and attempts are being made to introduce them in the cultivated types. This is exemplified in the case of cotton, where immunity to the pink boll worm is found in one of the American wild cottons, viz., *G. thurberi*. Breeding by interspecific hybridization, is very complicated and a knowledge of genetics and cytology of the crop is essential for planning out a proper programme of crossing. It is difficult to effect successful crosses in many cases and the hybrids obtained may exhibit sterility in varying degrees. In some cases the parents differ in the number of chromosomes, which are the organs responsible for the transference of most of the hereditary characters of the plant and which are of a definite number for each species. These organs take the form of minute thread-like bodies within the nucleus of the cell and can be distinguished only at the time of cell division with the aid of a high power microscope. These minute bodies range from as low as three in certain plants to more than 50 in certain species. Each chromosome preserves its identity during the whole life of the plant and is the carrier of a particular group of hereditary characters. Each chromosome is different from all the others in the factors they carry, in shape, size and other respects. In the reproductive cells of a normal plant (the male pollen cells and the female egg cells), the chromosome number is usually half that found in the vegetative or somatic cells. The reduction takes place at the reproductive phase, when the cells differentiate into pollen and egg cells. When fertilisation is effected by the union of male and female nuclei, a new cell containing twice as many but not the same chromosomes, as the reproductive cells is formed. The multiplication of such cells gives rise to new individuals.

In the case of interspecific hybrids effected with different species, the parental chromosomes being in many respects unlike though same in number, fail to pair and give rise to irregularity in the division of the reproductive cells. This leads to considerable sterility due to non-viability of the generative cells. In the case of interspecific crosses where the parental chromosomes differ in number, further complication arises during the division stages. It is on the above grounds that many interspecific crosses attempted by earlier workers have been abandoned or declared as waste of time. Results of practical value have nevertheless been obtained when the cytogenetics of the crops are properly understood. Notable examples are crosses between (*a*) Mexican Potato (*Solanum demissum*) and domestic types, (*b*) *Triticum vulgare* and *Yaroslav emmer—T. dicoccum* (in wheat) and (*c*) *Saccharum spontaneum* and *S. officinarum* (in sugarcane). The barrier of sterility

in interspecific hybrids has been overcome by back-crossing and by amphidiploidy. In all cases, chromosome balance is required for obtaining fertile progenies. To illustrate a back-cross example in cotton, the cultivated Asiatic species have 13 chromosomes in the reproductive cells while the cultivated Americans have 26 chromosomes. The interspecific hybrid with 39 chromosomes occasionally sets seed when back-crossed to the American parent and gives progenies with 52 and 65 chromosomes. The 52 chromosome plants are fully fertile, show regular pairing of chromosomes in the meiotic division and readily cross with cultivated American cottons. Amphidiploidy means a process by which the resultant hybrid possesses a complete set of the somatic chromosomes of both the parental species. In this case, doubling can take place either by the union of unreduced gametes known as gametic doubling or by doubling in the somatic cells known as somatic doubling. Since the hybrid possesses double the number of parental chromosomes and since each chromosome has a partner, there is regular pairing and the hybrid is fertile. Thus, if AA represents the somatic complement of chromosomes in one parent and BB in the other, the ordinary hybrid will have the somatic constitution AB. Since the chromosomes of A and B sets cannot pair, the hybrid is sterile. When doubling takes place in the hybrid, the fertile amphidiploid will have the constitution AABB. Economic varieties have so far been obtained only from wheat-rye hybrids representing intergeneric hybridization.

The chromosomes found in the reproductive cells are the haploid number while those present in the somatic cells are called diploid number. In the case of Asiatic cotton, 13 is the haploid and 26 is the diploid number while in rice, 12 is the haploid and 24 is the diploid number. If a plant arises directly from a gamete without fertilization by some method, the resulting plant will have only the haploid number of chromosomes in the somatic cells. These are called haploids. Many such haploid plants are reported in various genera as in rice, tobacco, mustard, cotton, wheat, maize, tomatoes, etc. The first reported case was in Datura by Blackeslee and his co-workers in 1922. The haploids are usually small, highly sterile and occasionally give rise to diploid progeny when self-pollinated. Such diploids are of great genetical value since they are perfectly pure. Sometimes, the somatic cells instead of showing the diploid number of chromosomes show double the number and the plants are then called tetraploids, as these have four times the number found in the reproductive cells of normal diploids. Tetraploids have been reported in a good number of crop plants like rice, bengalgram, sorghum, cotton, chilli, mustard, tomatoes, tobacco, *bajra*, wheat, etc. Such plants are usually large in size and exhibit indifferent fertility. They possess many advantages like wider adaptability and a greater range of crossability. When a diploid and a tetraploid are crossed, the resulting plant will have three sets of chromosomes in the body cells and the plant is then called triploid. Many of the cultivated apples, pears and banana

are triploids. In the case of crop plants, the frost-hardy variety of potatoes was a triploid. Like the tetraploids, the triploids are vigorous, show high degree of sterility but can be crossed occasionally with their parent types for obtaining fertile progenies. Other polyploid numbers like pentaploids, hexaploids, octoploids, etc., having respectively five times, six times and eight times the haploid chromosome numbers have been reported in a number of plants. In general, two types of polyploids known as auto and allo-polyploids are distinguished. In the case of the former, the polyploid arises through the duplication of chromosome number in a pure species, while in the latter it arises from a hybrid between two different species. For example, in the case of cotton the tetraploid obtained by doubling the chromosome number of *G. herbaceum* or *G. arboreum* is called auto-tetraploid, while the tetraploid obtained from the hybrid *G. herbaceum* × *G. arboreum* is called allo-tetraploid. Both auto and allo-polyploids have played their part in the establishment of new species in nature. Evidences are on hand to show that a large number of present day cultivated plants have polyploid origin and by gradual differentiation of chromosomes and natural selection, the polyploids have become gradually highly fertile and are functioning like normal diploids. A good number of synthetic polyploids have been obtained artificially and the new species so obtained compare favourably with the natural species. The use of chromosome duplication in the production of fertile, true breeding polyploids leading to the creation of new species has proved so promising that special methods have been developed to induce chromosome doubling. Earlier attempts to induce doubling in the callus tissue by cutting, was met with some success in the case of tomato, but this method did not prove useful for all the plants. Recently, the production of fertile polyploids with the aid of chemicals like colchicine, an alkaloid extracted from the roots of *Colchicum autumnale*, gave successful results in a wide range of plants and also sterile interspecific hybrids. In these hybrids the sterility was due to the non-homology of chromosomes derived by the parents. Most plant breeders have included the creation of polyploid forms in their breeding programme for producing greater variability and range of crossability, for building up types resistant to frost, drought, pests and diseases, and for improving the quality of crops.

Hormones.—Recently, there is a growing appreciation of the significance of a certain group of chemical substances in influencing plant development and a realization that simple chromosomal or nuclear relationships are not by any means the only deciding factors in determining this development. Plant hormones and special chemical substances which influence growth are responsible for many of the familiar phenomena like geotropic curvatures of stem or root or the photoperiodic curvatures of stem and leaves towards light. Recent investigations indicate, that all growth processes are influenced by growth substances of one kind or another. In coconut milk, a number of such growth substances are found and can be

used as culture media for small embryos excised from the plant. One of the substances prevents root growth, another causes proliferation of the cells and encourages cell division and yet another causes cell elongation as opposed to proliferation. The last substance is the one, which is responsible for controlling the growth of seedlings, stem curvature and many familiar phenomena of plant growth. It belongs to a group of substances called auxins which have a maximum activity at a dilution of one in 4,000. The typical function of auxins is to control growth of seedlings and the optimum concentrations are different for roots and shoots. Without auxins, no elongation takes place. Many agencies like X-ray, heat and light affect the auxins content. In the case of maize seedlings, ultra-short radio waves reduce the auxin content and cause reduced growth, which however is restored when synthetic auxin is applied artificially. From the point of crop improvement, auxins are useful for inducing root development in stem cuttings of plants that are not able to root normally. Most of the growth promoting hormones contain indole-acetic or indole-butyric acid in varying concentrations. Commercial patented products like 'Seradix' or 'Hortomone' are now available for large scale work. Hormones are also useful in the eradication of troublesome weeds. A number of patented weed killers like 'Methoxone' and 'Fernoxone' sold in the market will, if successful, go a long way in improving the crop yields and reducing the cost of cultivation.

Vernalization.—Although most of the characters follow the accepted laws of Mendelian inheritance, instances of non-Mendelian inheritance have been reported in recent years. The originator of this idea is the Russian scientist Lysenko, who propounded the theory of 'Vernalization', according to which growth and development are two distinct and separate phenomena capable of proceeding independently of each other. Development is supposed to take place in stages, each stage requiring a particular combination of environmental factors, which may be different for the different stages. Some of these factors are only required for one particular developmental stage and when this stage is completed they can be dispensed with altogether. The importance of the distinction between growth and development is, that if the factors required for the completion of each developmental stage are known and can be provided for the requisite length of time, all stages leading up to reproduction can be effected at any desired time even in freshly germinated seedling, without any growth taking place at all. Such seedlings when planted out will proceed to reproductive stage without any delay. By applying this principle, Lysenko was able to grow crops successfully in new tracts which were previously considered unsuitable for cultivation on account of very short growing seasons. Lysenko also proceeded to hybridise forms which were late in maturity owing to a delay in one phase, with forms delayed in another phase for producing early maturing hybrids. He found the progenies of winter wheat plants subjected

to partial vernalization, behaving mainly as spring forms and therefore he argued that by suitable ' training ', the hereditary nature of the plant or animal could be radically changed without recourse to hybridization. Another Russian scientist Michurin, a fruit breeder, advocated the methods of ' mentors ', which consisted of grafting on to a young hybrid in its early growth stages, a scion of an old established variety, whereby it was claimed that the hybrid acquired many of the desirable characters of the old variety. A great importance is also attached by the Michurin-Lysenko school to ' vegetative hybrids '. Some of the vegetative hybrids like ' Crataegomespilus ' which were later shown to be chimaeras, consisting of mixed tissues which have undergone no nuclear union, were claimed by Russian school as evidence that vegetative hybrids could not only be produced but behave in inheritance in exactly the same way as true sexual hybrids. The above facts led Russians to conclude that the hereditory constitution of a plant or animal is not fixed, as supposed by geneticists, but is subject to modification under the influence of the environment. The difference between the genetic school and the Russian school of thought is fundamental. The geneticists believe that the ' genes ' and all that go with them are unchangeable except by such processes known as mutation which occurs at random and are not capable of being directed or regulated by man. The Russian school believes that no difference exists between the reproductive tissues and the ordinary body tissues and changes exercised by the environment on the latter are transmitted to the off-spring. These changes could be directed and controlled and made to go in whatever direction the experimenter desires. So far, there has been no reconciliation between these two schools of thought.

Other accessory factors.—In the foregoing pages, an account of the crop improvement through evoluting of new varieties and treatment of seed, seedling or plant was outlined. Other measures like agricultural practices have also profoundly influenced the cropping capacity of soils. In such agronomic recommendations covering aspects like time of planting, seed-rate, pre and after-cultivation, rotation, manuring, irrigation and mixed cropping, substantial yield increases have been registered in most crops and put across to the farmers for general adoption. It is well-known that early sowing is in general advantageous to many crops and helps in minimising pest damage or evading frost and drought. Yields appreciate by 50 to 100 per cent in some cases. In cotton, early sowing in Coimbatore district has not only increased the yields by more than 40 per cent but has also saved two irrigations and rendered possible the planting of summer sorghum in March; at Siruguppa in the Bellary district it has minimised jassid damage; at Palur, the practice has reduced flower shedding and increased the yield threefold. On the other hand in the Punjab, late sowing and close spacing solved the defective opening of cotton bolls, otherwise known as ' *tirak* '. Similarly, close spacing of rainfed chillies at Guntur helped to dodge thrip damage to a small extent

through early maturity, while in the arid, low rainfall regions of Bellary wider spacing was found advantageous in crops like sorghum which was enabled to utilize the available moisture in an efficient manner. Conservation of soil moisture by bunding has improved the yields of crops like sorghum and other cereals, in the dry tracts of Bellary in the Madras State and in Bijapur and Sholapur in Bombay State. Crop rotations like planting rice after groundnut and cotton after groundnut have given better yields than cereal after cereal or cotton after cereal. Removing plant residues like sorghum stubbles immediately after harvest, in places like Coimbatore have benefited the succeeding cotton crops in the experiments conducted in the Madras State. Mixed cropping like cotton and groundnut or cotton and chillies have been helpful in yielding an increase in monetary returns compared to either of the two component crops grown in a pure state and has served as a cheap insurance against bad seasons and pest damage. Line and ridge planting in the case of most crops have helped in reducing after-cultivation expenses and in saving water especially during periods of water stress. Manurial trials have yielded very valuable information regarding the soil and crop requirements, suitability of different manures, optimum doses and the best time and method of applying them. Insufficiency of soil moisture is a limiting factor in the application of manures under Indian conditions. In general, all irrigated zones and rainfed tracts receiving not less than 30 inches per annum may with advantage be manured as most of the Indian soils are deficient in organic matter and nitrogen. The importance of manures to step up internal production has been well recognized. The addition of organic matter through off-seasonal cultivation of green manure crops not only adds to its nitrogen content but also improves the texture of the soil.

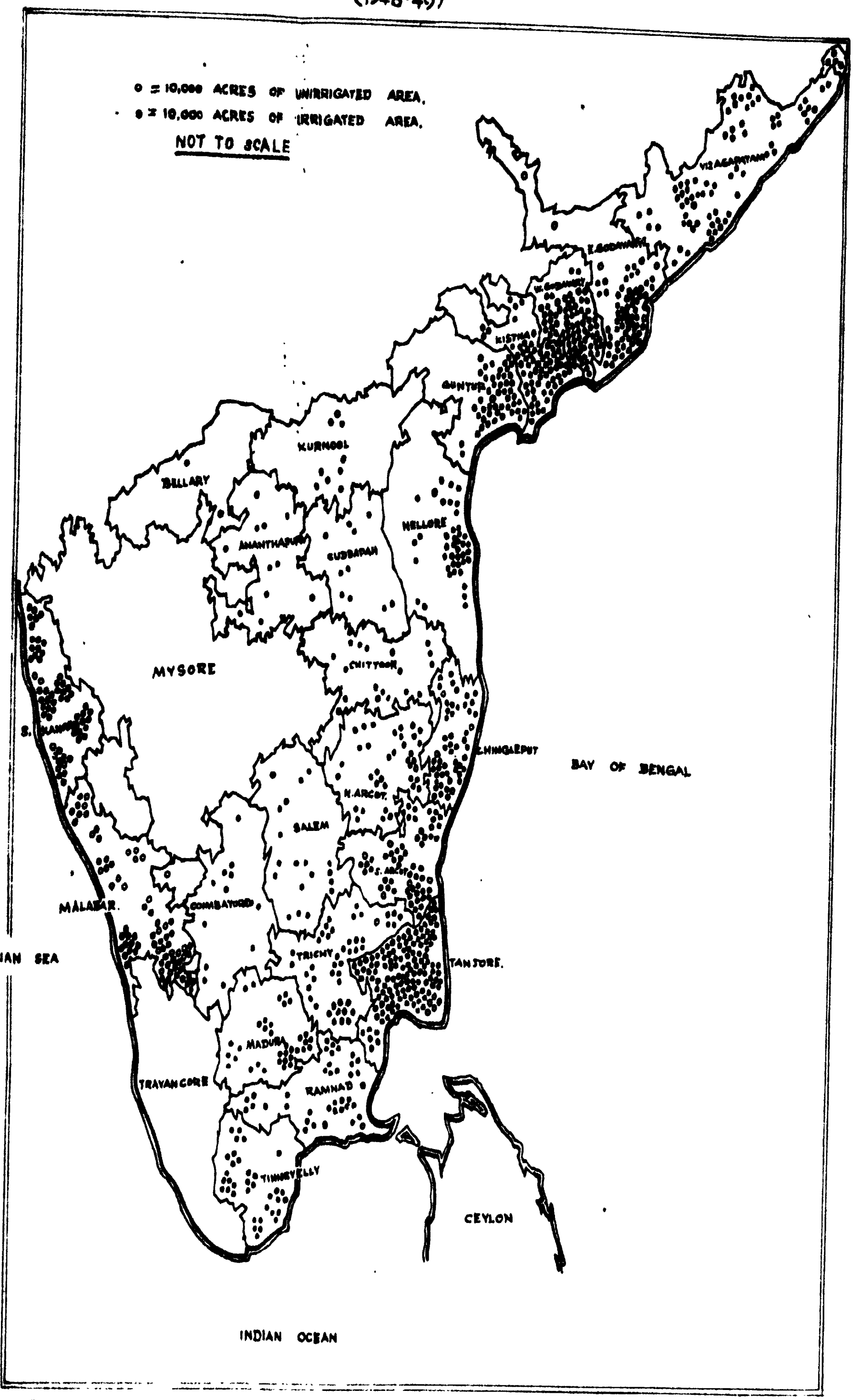
Statistics in crop improvement.—In crop breeding, agronomy, crop sampling studies, and in trials relating to varieties, soils, manures, planting dates, irrigations, etc., a large volume of information in the shape of figures, is collected. The data have to be tabulated and assessed properly without any changes or bias. Statistical methods serve such a purpose. The errors arising out of faulty layouts and personal observations have to be guarded against in estimating the worth of any treatment or any variety. For this purpose the experiments should be properly replicated and randomised. Fisher and his co-workers have, after carefully considering the various agricultural and soil factors normally influencing the crop performances, recommended a number of designs for field layout and the statistical method of interpreting the results in breeding studies, quality tests, genetical studies, agronomic enquiries or crop sampling. The main recommendations made in the case of breeding studies are (*a*) selection of plants on the basis of mean values of the population, (*b*) selection of promising combinations in hybrid generation crosses on the basis of mean of the replicates and (*c*) study of the genotypes in replicated families and progenies. The main object of applying the statistical methods is to separate

the hereditary from the environmental influences and to base our recommendations on a sound basis. The methods of sampling and the technique have been standardized in many crops in recent years and are being increasingly adopted in all kinds of agricultural and laboratory research. In genetical studies, statistics have been helpful in studying the relationship of the genes in one another and in locating the position of the genes on the chromosomes. In complicated cases of inheritance, it has been possible to grade the segregates into various groups and classify them. By suitable statistical tests, the exact nature of inheritance could be known. In field survey like crop cutting experiments, statistics have been helpful in securing precise information regarding the crop yields.

Organization of seed supply.—The improved varieties are evolved as a result of patient and careful work extending usually over a long period of time. These new varieties have to be multiplied and distributed to the farmers for being cultivated on extensive areas. It is therefore very important that the properties of the strains are maintained without deterioration. In order to achieve this object, special organizations are necessary to supervise all the multiplication stages of the varieties. In such an arrangement, it is customary to have primary and secondary seed-farms otherwise known as nucleus, inner and outer areas. In all crops, the first two stages are strictly controlled by isolating the area and in all stages the off-types are scrupulously removed by periodical examination of the crop, from sowing to end of processing stages, inclusive of bagging the seeds. The variations in methods are mostly due to the peculiarities of crops but the underlying principle is the same throughout. The State or individual Commodity Committees subsidize the seed production by meeting a portion of the costs of production or supervision or both. The seeds are tested for purity and viability before bagging and sold at competitive rates to growers. Seed production is a vital function of the Agricultural Department and on this function rests the translation of breeding research to actual fields. The extent of increases in yield estimated from crop surveys of new strains, varies from 10 to 40 per cent, and the crop sampling work done so far has supported the figures. As a consequence, in the case of cotton, the normal yields per acre adopted in Season and Crop Reports have been revised and upgraded. In other countries there are private organizations aiding the State in keeping up the quality of seeds. The 'Seeds Act' controls the production in a pure form. In India, such acts though not universal, are passed for controlling one or more commodities. 'The Punjab Act' covers all crops; 'Cotton Control Act' in Bombay and Hyderabad, applies to specified varieties; many States have safeguarded the production of horticultural plants. In the larger interests of the country, it is desirable to legislate and compel farmers of specified areas, to grow only improved varieties recommended by the Agricultural Department. This step alone will contribute by at least five per cent, in wiping out our production deficit.

DISTRIBUTION OF RICE CROP IN MADRAS STATE

(1948-49)



CHAPTER 3.

RICE (*ORYZA SATIVA*)

Area, zones of production in Madras—Cultivation practices—Varieties, introduction, trials, selection, hybridization—Botany and physiology of the rice plant—Cytogenetic studies—Agronomic, irrigation and manuring experiments—Rice Research Stations—Stationwar lists of strains evolved for each locality.

Telugu—Vadlu; Tamil—Nellu; Kanarese—Bhatta; Malayalam—Nellu; Hindustani—Dhan.

Rice is one of the very earliest crops to come under cultivation and has been known from the dawn of history. Many of our ancient scriptures contain descriptions of varieties of rice that are to be used in religious offerings. In China, the sowing of rice was observed as an important religious ceremony, as early as 5,000 years ago. The original home of rice is not known with any certainty; all that can be said in the present state of our knowledge is that it must be somewhere in South-East Asia.

Production and importance.—Rice is one of the most widely grown food crops of the world with an annual output of 120,000 to 130,000 million pounds, a figure that is almost equal to wheat. It forms the staple food of about one-third of the world's population. The area under rice in the world is estimated at about 190 million acres, of which 95·2 per cent is in Asia, 2·4 per cent in Africa, 1·6 per cent in America and 0·8 per cent in Europe. The important rice-growing countries in Asia are China, India, Japan, Indonesia, Burma, Indo-China, Siam and Korea. The production of rice in the different countries during the years 1934–38 to 1949 has been as follows :—

Country.	Yield of rice in million metric tons (as published by F.A.O.).				
	1934–38.	1946.	1947.	1948.	1949.
China	50·5	46·0	46·9	46·5	46·2
India	29·2	30·3	29·8	28·7	34·5
Japan	11·5	11·5	11·3	11·6	12·2
Indonesia	10.0	4·7	5·6	9·3	9·9
Burma	7·0	3·8	5·4	5·3	4·0
Indo-China	6·5	4·3	4·8	5·1	4·6
Siam (Thailand) ..	4·4	4·6	5·5	5·3	..
Korea	..	2·4	2·8	3·1	3·2
Phillipines	2·2	2·2	2·3	3·5	2·6
Formosa	1·6	1·1	1·2	1·5	1·7
Pakistan	11·2	12·8	11·8	11·6	12·4
Other countries (excluding Pakistan). ..	1·1	0·9	1·0	0·9	1·9
	135·2	124·6	128·4	131·4	133·2

These countries can be grouped into surplus countries like Burma, Siam and Indo-China and deficit countries like India, Ceylon and Japan.

In India, the chief rice-growing States are Madras, Bengal, Bihar, Madyha Pradesh and Orissa. The average area and production of rice in the several States of India are given below :—

States in India.	Area in 1,000 acres (1945-46).	Production in 1,000 tons (1945-46)
1 Assam	4,087	1,632
2 West Bengal	7,933	2,853
3 Bihar	9,738	2,458
4 Orissa	5,156	1,294
5 Madras	10,203	4,241
6 Bombay	2,093	821
7 Madhya Pradesh	6,071	1,641
8 Uttar Pradesh	7,045	1,837

Among the States, Madras stands first in area and production (Plate 4). The area under rice in the different districts of Madras for the year 1937–48 is as follows (Plate 3) :—

Table showing the average areas in the different districts of the States (1947–48).

Serial number and district. (1)	Irrigated. (2) ACS.	Unirrigated. (3) ACS.	Total. (4) ACS.
1 Tanjore	1,251,000	76,800	1,327,800
2 Malabar	..	875,000	875,000
3 Visakhapatnam	697,000	45,900	742,900
4 West Godavari	691,000	41,400	732,400
5 East Godavari	636,000	56,000	692,000
6 Chingleput	529,000	143,000	672,000
7 Krishna	618,000	16,900	634,900
8 South Arcot	528,000	78,300	606,300
9 South Kanara	..	589,000	589,000
10 North Arcot	501,000	36,000	537,000
11 Nellore	434,000	19,500	453,500
12 Guntur	414,000	36,000	450,000
13 Ramanathapuram	269,000	130,000	399,000
14 Tiruchirappalli	332,000	40,900	372,900
15 Madurai	357,000	9,980	366,980
16 Tirunelveli	359,000	2,140	361,140
17 Chittoor	228,000	24,600	252,600
18 Salem	220,000	7,200	227,200
19 Cuddapah	132,000	3,040	135,040
20 Coimbatore	127,000	1,320	128,320
21 Anantapur	101,000	1,710	102,710
22 Kurnool	67,000	10,400	77,400
23 Bellary	29,400	2,070	31,470
24 The Nilgiris	..	7,060	7,060
Total ..	8,520,400	2,254,220	10,774,620

It will be noted that rice is grown in about 11 million acres in this State with an annual production of about 4·9 million tons.

In the State of Madras, four distinct rice-growing zones can be distinguished : (1) the West Coast with a very heavy rainfall of over 100 inches with undulating land with low hills and valleys and laterite soils where rice is grown on terraced fields. On the higher slopes, only one crop is raised in a year, but further down

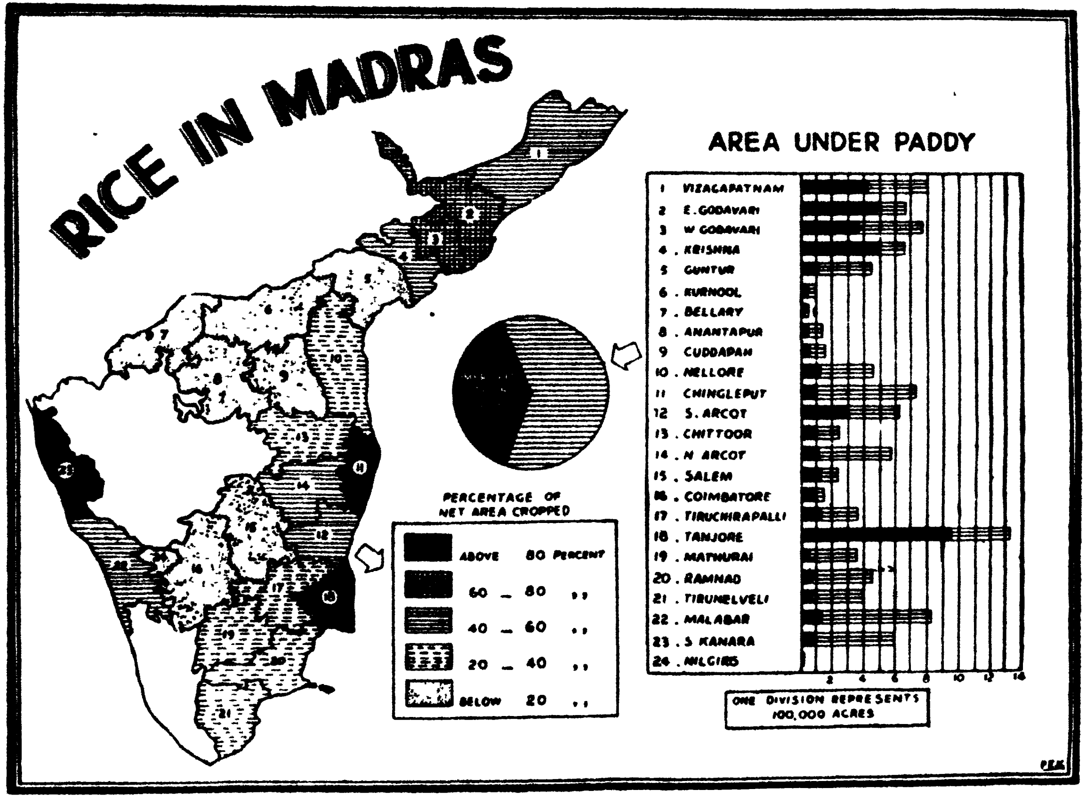


Plate 4.—Rice in Madras.

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in the valleys, two short crops of rice, one following the other are often grown; (2) the central and southern districts (Salem, Coimbatore, Madurai, Ramanathapuram and Tirunelveli) with low rainfall not exceeding 30 inches from both the south-west and north-east monsoons, where rice is grown with irrigation from seasonal rivers supplemented by water from tanks and wells; (3) the East Coast districts with a higher rainfall of 40 inches where rice is grown mostly during the north-east monsoon; and (4) the deltaic areas of the Godavari, Krishna and Cauvery rivers, where nearly half the entire rice production of the State is concentrated. Rice is grown in these areas with the aid of an efficient canal irrigation system supplemented by rainfall from both the monsoons. The area under rice irrigated under different systems is furnished below :—

	Area in million acres.
(1) Heavy rainfall conditions prevailing on the West Coast (South Kanara and Malabar)	1·5
(2) Low rainfall conditions	1·8
(3) Irrigated from tanks, mostly rainfed	3·5
(4) Irrigated from canals	4·0
Total ..	10·8

Habitat.—Rice is ordinarily cultivated as a semi-aquatic crop in the tropics and in sub-tropical regions and it can be grown from sea level up to an altitude of even 5,000 feet. High altitudes and low temperatures, however, delay flowering and maturity. It can also be raised on a wide variety of soils, from black clays to sandy loams, on light sand, and on gravel and even stony soils. The crop can also tolerate a certain degree of acidity in soils. Though it can be grown either as a wet or a dry crop, the majority of the rice grown in Madras is under the wet system of cultivation.

Dry cultivation.—Rice is grown as a dry land crop in parts of Malabar, South Kanara, portions of the coastal districts and in the Agency tracts of Visakhapatnam district. In Krishna and Godavari districts, rice is sown on dry lands in between rows of redgram. The variety used is known as *Budama* rice. In Chingleput, Nellore and Kurnool districts the crop is sown dry, but treated as a wet crop later, when water becomes available in the tanks with the onset of the north-east monsoon. In certain parts of North Arcot, South Arcot, Chingleput and Salem, rice is cultivated as a garden-land crop under well irrigation.

Wet rice.—This is the most widely practised system. The areas commanded by the irrigation systems of Godavari, Krishna, Cauvery, Pennar, Periar and Tambraparni rivers come under this category. There are also other minor irrigation systems of small rivers and large tanks in several parts of the State where wet cultivation is practised.

Seasons.—Three distinct seasons are recognized for rice in Madras—

(1) The south-west monsoon season—June-September.
(2) The north-east monsoon season—October-January.
(3) Hot weather (spring season)—February-May.

A hot weather crop of rice is raised between February and May in certain special tracts where water facilities are available, as for example in the Godavari delta. Most of the rice area in the State, however, is a single-crop area, where a fairly long duration variety of rice is grown. Where sufficient water is available, two crops are taken in succession, and in some limited areas as in the West Coast and Tirunelveli even a third crop of rice is grown in the same year. Where two crops are raised, one is usually of a short duration and the other of a long one. In the Cauvery delta and most other double-crop areas, the short duration variety is followed by the long duration variety, but in the Godavari delta, the long duration type comes as the first crop. In the districts of Tanjore and Tiruchirappalli, the short duration first crop is called "*Kar*" or "*Kuruvai*" and the long duration (second) crop, "*Samba*", "*Thaladi*" or "*Pishanam*". In the Telugu districts, the first crop which is of a long duration is known as the "*Sarva*" and the second crop as "*Dalwa*". (Plate 5.)

Preparation of land.—In the wet system, rice is either broadcast or transplanted, but in the heavy soils of the deltaic areas, the crop is invariably transplanted. The soil in these areas dries very hard after the harvest of the previous rice crop and forms deep fissures during the hot summer. The land is, therefore, left fallow until irrigation water becomes available, after which the fields are flooded, well soaked and then ploughed. If any green manure is available it is spread and trampled in. The fields are kept flooded and given three or four ploughings until reduced to a puddled condition. The fields are then levelled with a levelling board and made ready to receive the seedlings.

Sowing.—Dry seed is sown directly under rain-fed conditions while sprouted seed is sown in the puddle when swamp conditions exist. In dry sowing the seed is either sown broadcast and covered with a country plough or drilled in lines about nine to twelve inches apart and covered by a harrow. In some places paddy seed is dibbled in plough furrows at six to nine inch intervals and covered up by the next furrow. Most of the first-crop areas in Malabar on the West Coast, and dry and semi-dry areas in other districts are sown dry, with pre-monsoon showers or early rains of the south-west monsoon. Direct broadcasting of paddy seed under swamp conditions is adopted only when necessitated by special local conditions. The seed rate for dry sowings varies from 40 to 100 pounds per acre, according to the season, soil and moisture condition prevailing at the time of sowing.

Transplanting.—The bulk of the rice area in the Madras State is transplanted with seedlings raised in nurseries. The area of nursery varies according to local conditions of water-supply, soil

RICE SEASONS IN THE PRESIDENCY

REFERENCE
—Shows the periods of harvest

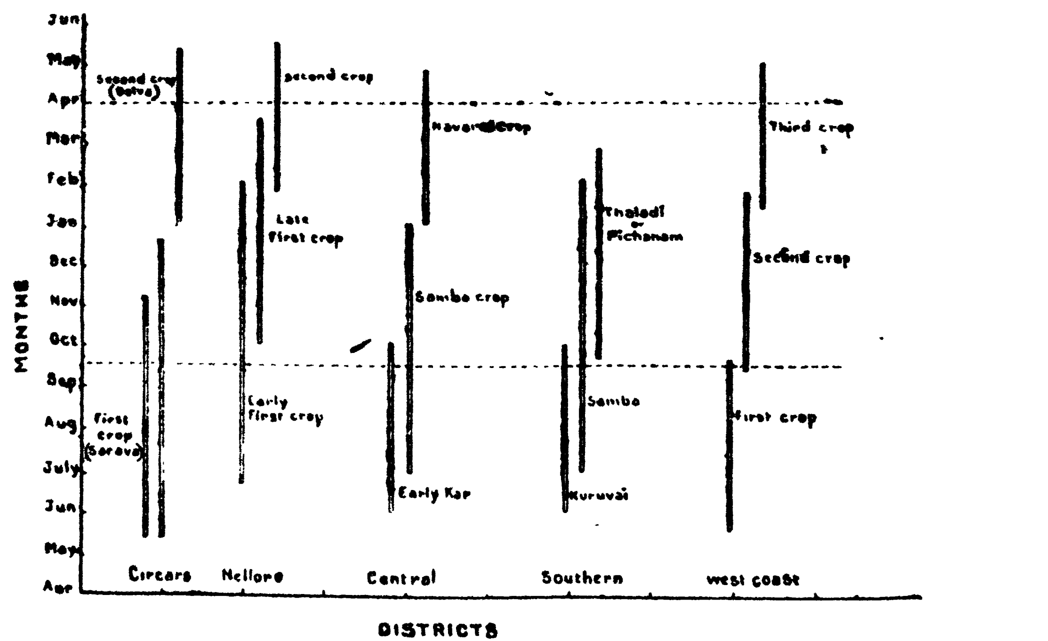

Plate 5.—Seasons for rice in Madras.

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type and the system of raising seedlings; from 5 to 12 sents of nursery area for planting one acre. Dry nurseries are manured with the available cattle manure or penned with sheep or cattle. Wet nurseries receive green leaf at the rate of four to ten thousand pounds per acre, in addition to cattle manure. Seedlings grown in seven cents of nursery area, sown at three pounds per cent, provide the right type of sturdy seedlings for planting one acre, six inches apart in singles. In dry nurseries, this seed rate has to be higher, at four pounds per cent to allow for possible casualties later on, as the seedlings in a dry nursery remain in the field much longer than in wet nurseries. Wet nurseries are preferred in areas where the planting time could be forecast with certainty, while dry nurseries are adopted in areas where the receipt of water for planting is not so definite. Seedlings in dry nurseries can be kept longer in field without detriment to subsequent yields. The seedlings are kept down in growth by restricting the water-supply, and they get pale and hardy, with congested nodes. When these seedlings are planted later in a well-puddled field, they strike root rapidly and commence tillering. If seedlings in a wet nursery are kept for longer than the optimum period, the internodes elongate, and such seedlings when planted take a longer time to strike root and are also poor in tillering. Hence, in some areas, even wet nurseries are allowed to partially dry up, so as to harden them in the same manner as seedlings in dry nurseries.

Experiments have been conducted on the manuring of seed-beds for rice, and they indicate that for good yields it is necessary to manure both the nursery and the transplanted fields, but the latter is more important.

Special methods of cultivation.—There are in Madras, some special systems of growing rice, evolved to suit special local conditions. These are briefly described below :—

"*Udu*" *system of cultivation.*—This system is practised in certain parts of Tanjore district, where planting of the second crop is not feasible on account of too much water in the fields during October-November. Seeds of a short-duration (*Kuruvai*) variety are mixed with a long-duration (*Ottadan*) variety in the proportion of 3 :1 and sown in the nursery in June. Three weeks later the seedlings are planted in bunches of six to ten per hole to ensure the inclusion of one or two long-duration seedlings in each clump. The short-duration variety matures by September, when the long-duration type is still in the vegetative stage. The *Kuruvai* crop is harvested leaving a long stubble of six to twelve inches and the field then flooded. The *Kuruvai* stubble gets decomposed to serve as manure, while the *Ottadan* plants, though they get topped to some extent during the *Kuruvai* harvest, make a good growth afterwards. The water is drained off after standing in the field for a week and the rotten *Kuruvai* stubbles are combed out and trampled in between the *Ottadan* plants. Thereafter these *Ottadan* plants grow normally and get ready for harvest by the end of February or early in March.

"*Kaipad*" *system.*—This system is practised in certain saline and marshy areas of North Malabar, near river mouths subject to tidal influence and needs an intimate local knowledge regarding field levels and tidal movements. Early in summer, the areas proposed for this type of cultivation are enclosed with wide, strong bunds forming large plots, with sluices connected by a system of channels. Towards the end of the north-east monsoon, in October-November, water is let into these plots and allowed to stand till February to facilitate the decomposition of the pre-existent vegetation. In February or March, this water is drained off and the plots are laid out in small mounds about a yard in diameter at the base and two feet high. During the first heavy rains in next June, all the salts get washed off from the mounds. The tops of these mounds are then levelled and a handful of sprouted seed sown on the top. When the seedlings are a month old, the mounds are broken up with a spade in such a way that seedlings are removed with a sod of earth and spread all over the field to give the appearance of a planted crop. These seedlings make good growth with the aid of the heavy rains that are received during July-August in Malabar and come to harvest in October. The earheads alone are harvested as the water standing in the plots cannot be drained by October. The varieties cultivated in these "*Kaipad*" areas are: "*Kuthiru*", "*Kayama*", "*Bali*", "*Ezhome*", etc. The yields range from 1,500 to 3,000 lb. per acre.

"*Kole*" *system of cultivation.*—This system too is confined to the coastal region of Malabar, Cochin and Travancore, on very low-lying areas where no cultivation is possible during the regular monsoons. Operations commence only by December after the cessation of the north-east monsoon, when the water level in these areas had gone down sufficiently. First, large plots are formed with high bunds and wide channels in between. When the water level recedes during December-January, water from the plots is baled out into the channels either by manual labour or with the aid of pumps and oil engines. These channels then serve as storage places for water. The land is soft and miry and the required puddle is secured by mere levelling. Sprouted seed is sown in this puddle, the usual varieties being *Thekkan cheera* and *Karutha cheera* with a duration of 90 to 105 days. As the crop grows, the water stored in the channels is baled back into the plots to serve as irrigation water.

Rotations.—No regular rotations exist in areas where rice is cultivated under swamp conditions and the bulk of the area is cropped year after year with only rice. However, there is a practice in the northern deltas of taking a catch crop of sunhemp or pillipesara for fodder, or pulses like greengram or blackgram, by sowing the seeds in the standing rice crop just before its harvest. These catch crops are able to grow with the residual moisture in the fields that had been under water for nearly six

months. In certain favoured localities, where the land is rich and well-drained with abundant water facilities, sugarcane, bananas, betel-vine or turmeric are rotated with rice once in three or four years. In areas where the water-supply in summer is not sufficient for taking a rice crop, millets like sorghum, *bajra*, or ragi, or oilseed crops like sesamum or groundnut or cotton are grown between February and September. Where rice is grown as a dry-land crop, it is usual to rotate it with other rain-fed crops like sorghum, groundnut or sesamum. Mixed cropping is also practised occasionally in certain limited areas, with rice and other slow growing crops like redgram or cotton.

Varietal collections, introduction and trials.—There are three obvious ways of increasing production in any crop, namely, by increasing the area under cultivation, by enhancing the acre-yields in the area cultivated and by preventing loss during the various stages of cropping and storage of the crop. In the case of rice, it must be admitted that, in spite of all the concessions granted by the Government, no spectacular increase has been possible in the present stage of irrigation facilities in the Madras State. The problem of utilizing uncultivated waste lands for rice cultivation is one that can be solved only by a long-term programme, in relation to the various dam projects that are now suggested, though it might be possible to convert some single-crop lands into double-crop wet lands for rice, with minor improvements here and there to existing tanks and irrigation systems.

Increasing the yield per acre can be done in two ways, by using the soil to better advantage with the help of better manures and better irrigation and by using high-yielding varieties evolved by the Department of Agriculture. Pests and diseases take a heavy toll from the potential yield of any crop and rice is no exception to this type of loss. Effective measures to prevent the loss would help a great deal in increasing rice production but here again a permanent remedy would only be the evolution of high-yielding disease-resistant strains. For special areas subject to floods, drought or alkalinity, special varieties are needed that are capable of giving satisfactory yields under such adverse conditions. The Paddy Breeding station at Coimbatore and the several research stations in the State are engaged on this vital problem of increasing production on a wide front, including all the above lines of investigation. These are described in the following pages.

Improvement of a crop by breeding comprises the following lines: (*a*) Varietal collection and introduction, (*b*) pure line selection, and (*c*) hybridization and other methods. The collection and maintenance of pure varieties of rice from as many sources as possible is very important for a successful breeding programme and has been followed with great care in the paddy section from its very inception. The history of every culture is recorded by a simple yet foolproof system devised in the Paddy Breeding Station, there being to date nearly 2,000 types collected from all over

India and other rice-growing countries of the world. This valuable collection forms, as it were, the store house for selecting parents of crosses for genetic studies or economic varieties. The wealth of morphological and economic variations available in this collection makes it a very valuable training ground for all rice breeders. A large number of extracted types, (derived from the progenies of crosses) interesting genetic material, wild spices and forms of *Oryza sativa* are also maintained in this collection.

Introduction of varieties.—An early attempt to introduce foreign rice varieties into Madras may be mentioned. Carolina paddy was obtained from America and grown in 1868 in the Central Jail, Chingleput, by the Jail Superintendent, both as a wet and dry crop. The trial was continued for four seasons and it was found that indigenous rice varieties proved better under conditions quite unfavourable for Carolina rice. In later years, a number of American, Chinese, Japanese and Italian types have also been tried in different seasons in the Paddy section at Coimbatore but none was found good enough to thrive under Coimbatore conditions. They come up fairly well in the first year or so, but soon get less and less promising in subsequent years. Chinese varieties were, on the whole, the most promising amongst these foreign varieties.

Among successful varieties introduced into Madras from other parts of India may be mentioned the varieties "*Basumathi*" of the Uttar Pradesh and "*Patnai*" of Bengal. *Patnai* is a heavy yielder grown in Coimbatore in the Bhavani Project area, while *Basumathi* is valued for its aroma and flavour for *Biriyani* and allied preparations. Another variety called SR. 26B, from Orissa, comes up well in saline areas. Trials with deep water paddies from Assam and Bengal such as "*Harisanker*", "*Baital fakir*" and "*Panian-la*" were not successful under the condition available in this State.

Evolution of strains—By selection.—The rice varieties grown in and around Coimbatore district were naturally the first to receive attention when the Paddy Breeding Station was started in 1913 at Coimbatore. Later, the varieties grown in other rice areas, where the system of cultivation was similar to Coimbatore, were taken up. Special surveys were also made of other areas and preliminary studies on these varieties were made at Coimbatore. As a result of following the method of progeny selection over a number of years, and testing the promising types with greatest care both in the research stations and in cultivators' fields, twenty-one strains numbered CO 1 to CO 23 (barring CO 14, 15 and 16) and GEB 24 have been evolved. (Plate 7.) Due to the great care taken to test every new selection before it is released as a strain, the cultivator has never found his confidence misplaced in any of the Paddy section strains. Special mention may be made here of GEB 24, an outstanding strain of high quality, yielding capacity and adaptability to a wide range of cropping conditions both in Madras and in other States. (Plate 6.) It is stated to be grown with success in Sierra Leone and is a popular variety in Mysore,

Plate 6.—*A good crop of G.E.B.* 24 (*Rice*).

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Plate 7.—Field study of rice varieties.

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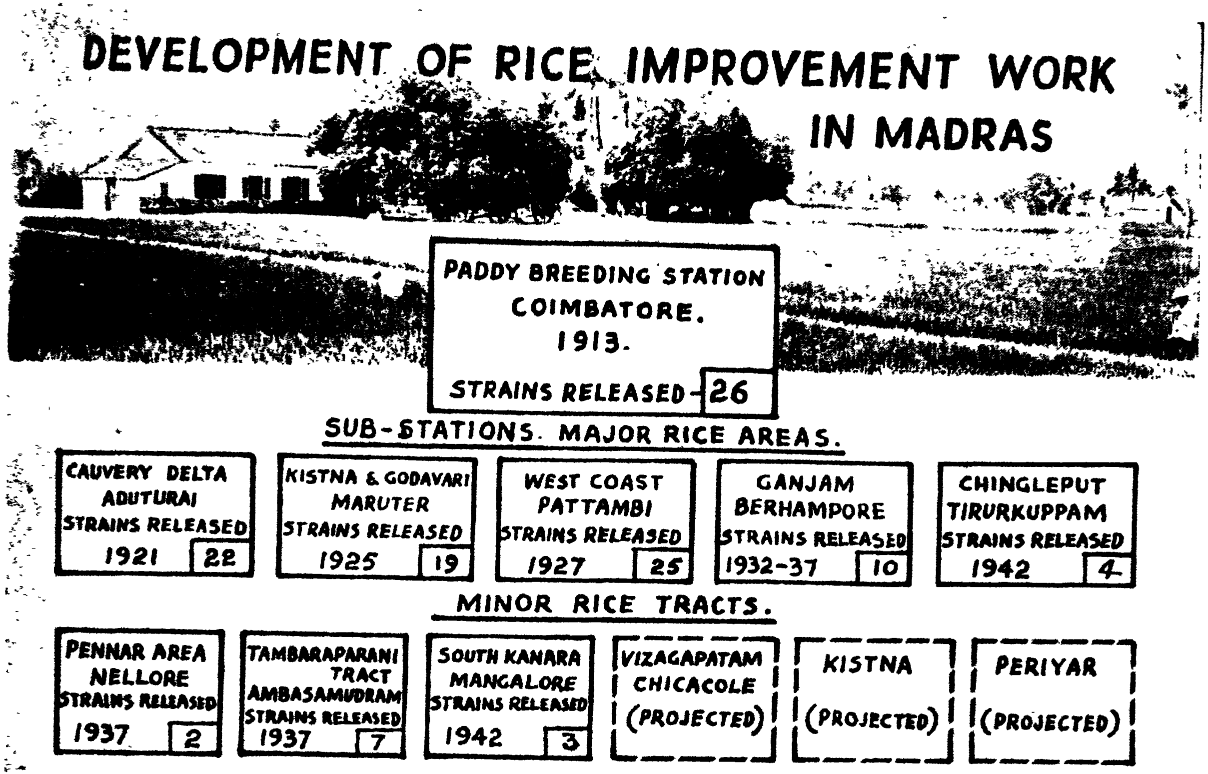


Plate 8.—*Sub-stations for rice research.*

In almost every case, increased yield has been the aim in the evolution of improved strains. The strains already evolved have spread over large areas in the different rice growing regions in Madras and they give an increase of never less than ten per cent over the local varieties, and often, much higher. In certain tracts, a shorter duration is required without diminution of yield and it has often been found possible to secure an earliness of a week or ten days by pure line selection alone, without detriment to yields. In many cases, it has been found that the strains released from the Paddy Section possess, in addition to higher yields, other ancillary features like uniform ripening, better quality rice, good straw, non-shedding grain and disease-resistance.

An important limitation in selection work, however, is that one cannot be sure that a strain suited for one tract, with one set of agricultural conditions would be equally suitable for another tract where the conditions are somewhat different. It is the exception rather than the rule that a strain is so adaptable (as for example GEB 24), for a wide range of conditions and tracts. It is, therefore, necessary that selection of improved strains should be carried out in each of the important rice-growing regions of the State. With an early realization of this necessity, the expansion of the Paddy Section work at Coimbatore took shape in the opening of a number of regional sub-stations, one in each of the important rice tracts of the State.

At present, rice research is being carried out in the following Agricultural Research Stations, besides the Central Station at Coimbatore. (Plate 8.)

Station.	District.	Opened in the year.
1. Samalkota	East Godavari	1902
2. Palur	South Arcot	1905
3. Anakapalle	Visakhapatnam	1913
4. Paddy Breeding Station, Coimbatore.	Coimbatore	1913
5. Aduthurai	Tanjore	1921
6. Maruteru	West Godavari	1925
7. Pattambi	Malabar	1927
8. Pattukkottai	Tanjore	1935
9. Buchireddipalayam	Nellore	1937
10. Ambasamudram	Tirunelveli	1937
11. Tirurkuppam	Chingleput	1942
12. Mangalore	South Kanara	1942

The improved strains evolved in these stations are described in the statement given at the end of this chapter.

Hybridization.—The selection of superior stains from unselected ryots' bulk was practised as long as it paid. In 1917, hybridization work was commenced in rice in view of its wider scope and greater possibilities for combining desirable economic characters from different strains. The method, although it did not quite achieve this specific result in the manner that was expected, nevertheless proved extremely useful from a genetic point of view and a great volume of fundamental knowledge was gathered on the

inheritance of various characters in rice, including economic characters like non-lodging, non-shedding of grain and disease resistance. (Plate 9.)

The periodic occurrence of a serious disease, known as the 'Paddy blast' caused by a fungus named *Piricularia oryzæ* and the heavy damage it caused, necessitated the evolution of blast resistant strains suited for the different rice-growing areas in the State. The disease appears as brown spots on the leaves with ashy-grey centres, which enlarge and coalesce until the whole leaf turns brown and shrivels up. On the older plants, the attack is more severe at the nodes and in severe cases the fungus attacks the "*neck*" or the spot where the stalk and panicle join. An infested field presents a blasted appearance and the crop suffers heavy losses.

Breeding for blast resistance was started in 1927 at the Agricultural Research Station, Aduthurai, and at Coimbatore in 1928. Numerous crosses were made between different varieties and their progenies tested for resistance to paddy blast over a number of generations. On account of the wide disparity in the duration of some of the parents used for inter-crossing, special delayed sowings had often to be made in order to get the varieties to flower at the same time. The strain GEB 24 was used as one of the parents in the earlier stages of this hybridization work but it was only partially resistant to paddy blast and hence another selection CO 4 (from Gobichettipalayam Anaikomban) which was much more resistant to the disease, was used as a parent for crossing with ADT 10, the premier variety of the Tanjore tract which was extremely susceptible to paddy blast. In years when the disease was not in evidence in the area where the trials were conducted, it was a problem to induce the disease for assessing the relative resistance of different cultures. Pot culture studies were too limited in scope as the results therefrom had again to be confirmed under field conditions. High level doses of nitrogenous manures were also tried as a means of increasing the susceptibility to the disease and ultimately it was found that large-scale artificial infection of experimental plots with *Piricularia* susceptible varieties together with heavy nitrogenous manures was the most effective method of testing the resistance of the progenies of crosses.

As a result of such patient investigations extending over several years, four resistant strains have been evolved, CO 15 and CO 16, from crosses between GEB 24 and ADT 10 and CO 25 and CO 26 from crosses between CO 4 and ADT 10. Some more resistant strains that are suited for other tracts and seasons are expected to be shortly available for large-scale distribution.

An important point that was noted in the course of this blast resistance work was that a resistant variety does not remain resistant for all time, but breaks down after some years, due presumably to the natural isolation of more virulent strains of the pathogen responsible for paddy blast. This feature naturally complicates the

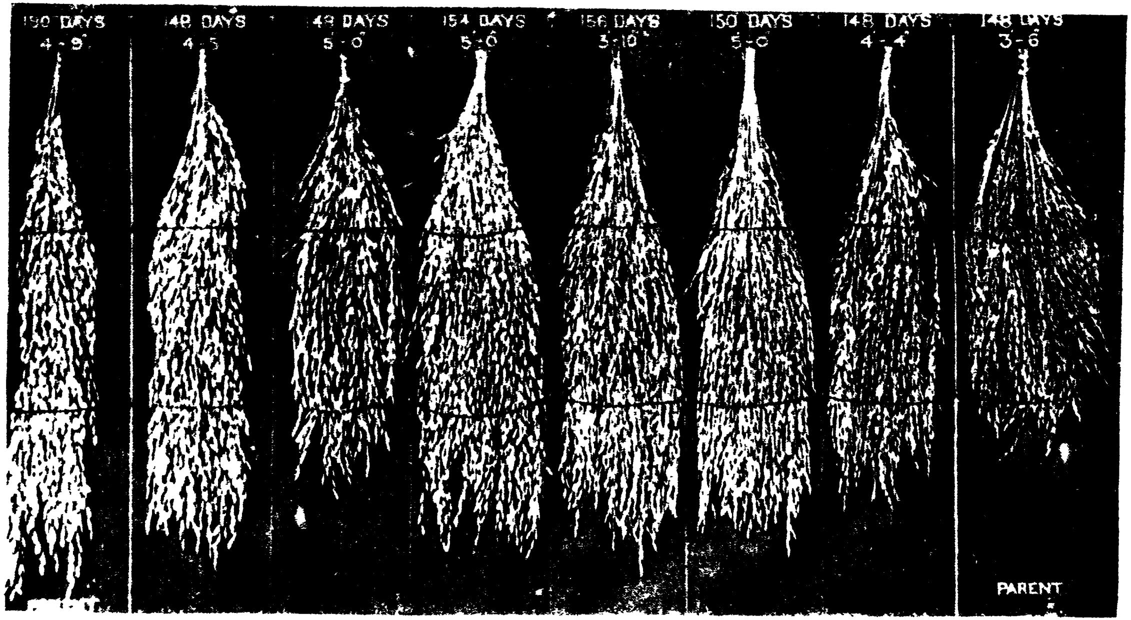


Plate 9.—Progenies from a cross and parents—Rice.

P. 45

B

A

Plate 10.—*Rice varieties and paddy blast.*

A = *ADT* 10 (*Susceptible to blast*). *B* = *Co.* 25 (*Resistant to blast*).

P. 46

problem still further and makes it necessary to pursue the work of disease resistance as a more or less permanent feature of any programme of rice research. (Plate 10.)

Breeding for saline resistance.—The occurrence of saline and alkaline soils is often a serious impediment to the extension of rice cultivation in some districts like Tanjore, Tiruchirappalli, Chittoor and Madurai, as none of the important rice varieties possesses any real tolerance to such an adverse soil condition. A few minor varieties are no doubt cultivated in these areas under a popular belief of their being able to withstand salinity, but these varieties are as a rule inferior types from the commercial point of view and it is, therefore, necessary to resort to hybridization to combine the two qualities of salt-tolerance and commercial quality.

About thirty varieties which had local reputation of being resistant to alkalinity were first tested in pot cultures at Coimbatore with varying proportions of alkaline plus normal paddy soil. Sixteen bottomless cement tubs measuring 33 × 33 × 20 inches were imbedded in the field with their top rims projecting a few inches above the ground level. These tubs were then filled with equal weights of soil of uniform texture and quality to which was added common salt to maintain a concentration of 0·50 per cent and 0·25 per cent. Eighteen seedlings were grown in each tub, with a spacing of four inches between seedlings. Another set of experiments was conducted in glazed pots without being buried in the field, but containing paddy soil with a salt concentration of 0·25 per cent and ten seedlings per pot.

These experiments showed that where the drainage was satisfactory, the growth also was good, the plants being able to withstand up to 0·25 per cent salt concentration, but when the drainage was defective most of the plants succumbed in all except a few varieties like *Thellathokavadlu*, *Kallimadayan*, *Vellakattai*, *Orkayama*, *Bali*, *Kuthir*, *Ezhome*, *Kalarata*, *Burarata* and *Kare patni*.

Further studies revealed that the Chittoor variety *Thellathokavadlu*, a very coarse grained type, was saline-resistant to a high degree. Crosses were accordingly made between this type (T 892) as the common male parent and some good quality Coimbatore strains like CO 4, CO 10, CO 13, CO 23, and ASD 2104, ASD 1205 as female parents and from the progenies, 258 salt-resistant cultures were selected and purified by 1947. In addition to these, another set of 483 fresh selections was also made in 1948 and studied at the Paddy Breeding Station, Coimbatore, as well as in the neighbouring ryots' alkaline fields during 1949. Selections from five hybrid bulks of a very early group of crosses yielded 38 saline resistant cultures suitable for testing in typical alkaline tracts of the State. Nine Bombay varieties and 35 district varieties were also collected for trial as alkaline resistant types in different alkaline tracts. Further crosses between T 892 (*Thella Thoka Vadlu*) and longer duration varieties that were reputed to be

drought resistant have also been made in 1948 and are now under detailed study. A variety from Orissa SR 26B is found to do well in places with moderate amount of salinity as also alkalinity.

Breeding for flood resistance.—To secure a high-yielding strain capable of withstanding submergence for long periods, crosses were effected in 1932 between GEB 24 and a floating type of paddy obtained from Burma. The progeny of this cross did not yield any promising type. Fresh crosses were made in 1943 between "*Kavinginpoothala*" (PTB 15), a variety popular in low-lying areas in Malabar and "*Rajakayama*" a short-duration variety of South Kanara, a medium-duration culture (No. 10783), and "*Kathuvanam*" a long-duration variety. All these varieties were reputed to be able to stand submergence. The F_3 progenies when examined in 1942–43, showed a number of well-tillered, non-lodging plants in *Kavinginpoothala* × *Kathuvanam* crosses, and tall plants with stiff straw in *Kavinginpoothala* × No. 10783 crosses. Yield trials were made during the next season choosing some of the most promising cultures from these crosses, and a few were found to give higher grain and straw yields than the controls.

At present five cultures in PTB 15 × No. 10783 crosses, having the same duration as PTB 15, and tall and stiff straw and two cultures from the cross PTB 15 × *Rajakayama* are under trial at Coimbatore and a few other districts. Crosses were made between some of the flood-resistant types from Burma and the local varieties at Maruteru and promising progenies have been selected for trial in deep-water areas.

Crosses for special purposes.—Crosses have been made at the Paddy Breeding Station, Coimbatore, as well as in some of the sub-stations with the object of evolving a cosmopolitan strain, by combining the useful characters existing in different strains. The problem is a complex one and does not admit of any solution within a short period. A few instances are, however, given to indicate the line of investigation that is being followed.

Crosses were made at Coimbatore to combine the close-set panicle and fineness of the Kolamba strains with GEB 24. One culture was well-bunched with good quality rice and is under trial at present. Crosses were also made between wild paddy varieties and high-yielding strains and a large number of promising types are under test for drought resistance. In many cases such crosses with wild paddies were found to be sterile, especially in the following combinations :—

1	Oryza sativa	× Oryza officinalis	(1934)	Coimbatore.
2	„	× Oryza glaberrima	(1938)	„
3	„	× Oryza longistaminata	„	„
4	„	× Oryza longistaminata Var fatua ..	(1934)	Berhampur.
5	„	× Oryza sativa, var. fatua	„	„
6	„	× Oryza officinalis X Oryza eichengeri.	„	Coimbatore.

Though sterile, these crosses provided very interesting material for cytological studies and helped to extend our knowledge of the taxonomy of rice.

In the cross between GEB 24 and *Oryza longistaminata* certain types were found to be much more drought resistant than GEB 24. These are under trial at Tirurkuppam under the semi-dry conditions that obtain there for testing their resistance to drought.

In another cross between "*Bayyahunda*" and "*Oryza spon Var. fatua,*" made at the Rice Research Station, Berhampur (now transferred to Orissa State) a few types which were vigorous in growth and had non-shedding grain were isolated. These were handed over to the Department of Agriculture, Orissa, when the Research Station was transferred.

In addition to the crosses mentioned above, a large number of other crosses made between high-yielding strains and "*Spontanea*" forms from other States and other countries are in various stages of study.

A list of strains evolved after hybridization is given with brief descriptions in each :—

Other methods—Mutations in rice—X-ray.—Mutations were induced in GEB 24 by subjecting the germinating grains to the action of X-rays and a systematic study made in order to isolate desirable types among them. Some of these mutations were gene-mutations affecting specific characters like grain size, pigmentation of glumes, awn development and chlorophyll, while others were mutations of chromosomes involving partial or complete sterility. Some had abnormalities like chlorophyll deficiencies, narrower leaves, dwarf habit and different grain shapes. Two types of economic value were, however, discovered among the progeny of X-rayed seeds. One was a dwarf mutant and the other consisted of cultures of extra tallness and late habit. The dwarf types had a profuse tillering capacity and did not lodge even with heavy manuring. One of them, No. 5782, is in demand from the rice-growing areas of Bellary and Anantapur districts. In the tall mutants, the straw yield was higher, but the grain yield was not better than GEB 24 and the ripening also was later by a fortnight, so that further study is needed before these tall mutants could be utilized as improved strains.

Particulars of strains evolved by hybridization.

Strain number. (1)	*Time of harvest or duration in days.* (2)	*Other particulars.* (3)
Samalkota—		
SLO 17. Gutti Kichili. (MTU. GEB. Nx 3).	Fourth week of November.	This is a natural cross isolated at Maruter from GEB 24 (Kichilisamba) with the same duration, but giving 12 per cent enhanced yield over GEB 24. Average yield per acre is 4,300 lb. *Grain size*: L—7·8 mm; B—2·4 mm; T—1·8 mm; *Glume colour*: Straw; *Rice*: White.
SLO 18. Pedda Kichili. (MTU. GEB. Nx 70).	First week of December ..	This is outstandingly the best among eight natural cross selections from GEB 24 (*Kichili samba*) evolved at the Maruter station. It can be grown in place of *Atragada* or other long duration varieties in loamy soils or sandy loams in the tail end of the delta or coastal lands where drainage water does not go down soon. An average acre yield of 4,000 lb. is recorded. *Grain size*: L—7·8 mm; B—2·6 mm; T—1·9 mm; *Glume colour*: Straw; *Rice*: White.
Maruter—		
MTU 15. Dalwa sannam.	125–130 days	This is a hybrid strain isolated from a cross between *Garikasannavari* and *Nallarlu* of the Godavari delta. Unlike Nallarlu it stands early planting in January and has all the good characters of *Garikasannavari*. It is comparatively less shedding and non-lodging. It is a week later than MTU 9 (*Garikasannavari*) and yields from 5 to 20 per cent over it, according to the season and manurial treatments. It is recommended in areas of the Godavari district where there is no dearth of water-supply for the "*Dalwa*" crop. Though released recently this strain occupies 60 per cent of the total second crop area with an average yield of 2,850 lb. *Grain size*: L—8·3 mm; B—2·5 mm; T—1·9 mm; *Glume colour*: Straw with purple tip; *Rice*: White.
MTU 16. Badava Kusuma.	Beginning of December ..	This is isolated from a natural cross between Konamani and a deep water type from Burma. Its chief characteristics are, tall growth, with thick straw, non-lodging habit. It can stand occasional submersion during its growth. It is recommended for low-lying places in the Northern Circars known as '*Badava*' or '*Ava*' lands and lands subject to inundation on either side of big drains in the coastal taluks of Godavari, Krishna and Guntur districts. This has proved to be useful on lands on the fringe of the Collair Lake between Krishna and West Godavari districts. The rice is coarse. *Grain size*: L—8·5 mm; B—2·8 mm; T—2·0 mm; *Glume colour*: Straw; *Rice*: White.

MTU. 19 Sanna kusuma.	First week of December ..	This is a strain—X-12 extracted from a natural cross in GEB. 24 at Maruteru. Extensive trials show its suitability for Krishna and Guntur districts under varying soil conditions. Its size of grain is finer and the quality of rice is better than MTU. 7 (*Gutti Kusuma*). It also matures a week earlier and yields 7 to 22 per cent higher than MTU. 7. It has recorded a maximum yield of 4,500 lb. in the trials at Vijayavada, with an average yield of 3,630 lb. per acre. Does not grow tall or lodge even on rich and well drained soils. *Grain size*: L—7·6 mm.; B—2·5 mm.; T—1·8 mm.; *Glume colour*: Straw; *Rice*: White.
Coimbatore—		
CO. 14 Perumthandu Vellai samba.	Second week of December.	This strain is the hybrid culture 10905, isolated from a cross made between CO 3 (*Vellaisamba*) and a tall Burma variety and has bunched ears and stiff straw. The strain combines the straw quality of the Burma type and the grain and rice quality of CO 3 (*Vellaisamba*). It is about ten days longer in duration when sown in June-July and yields 10 per cent over CO 3. It has established itself in the Salem district and is also recommended to South Kanara for the second crop season. It has recorded an acre yield of 3,000 lb. to 4,000 lb. *Grain size*: L—8·6 mm.; B—2·6 mm.; T—2·0 mm.; *Glume colour*: Straw; *Rice*: White.
CO 15 Jada Molukolukulu.	Third week of January ..	This is a hybrid culture 10998, isolated from a cross between GEB 24 (*Kichilisamba*) and ADT. 10 (*Korangu samba*) of Tanjore which is highly susceptible to *Piricularia* (*Paddy blast*). The strain yields up to 15 per cent over the local variety of the same duration, when the disease is not observed. But in the years when the disease breaks out, the yield of the strain may go up to 50 per cent over the susceptible local variety. As its ear is bunched and the grain size and colour resemble *Molakolukulu*, the strain is named *Jada Molakolukulu*. This strain, in preference to CO 16 (*Bontha molakolukulu*) is recommended to areas where paddy is grown for the raw rice market, as in Nellore, Cuddapah and Krishna districts. *Grain size*: L—7·7 mm.; B—2·9 mm.; T—2·0 mm.; *Glume colour*: Dirty in furrows; *Rice*: White.
CO 16 Bontha Molakolukulu.	Do. ..	This is another hybrid culture 11348, isolated from the same cross as CO 15 (*Jada Molakolukulu*). It is also highly resistant to blast (*Piricularia oryzæ*), and gives higher yields than *Molakolukulu* or *Nellore samba*. It resembles more or less *Molakolukulu* or *Nellore samba* except for a bigger grain and a coarser build of the plant. It is also of a non-shedding habit. It is recommended for making par-boiled rice in southern districts. It has recorded an average increase of 15 to 20 per cent over local standard in normal years and it yields up to 50 per cent over the same when the disease breaks out. As the size of the grain is coarse, the strain is named '*Bontha Molakolukulu*. *Grain size*: L—8·1 mm.; B—3·1 mm.; T—2·0 mm.; *Glume colour*: Dirty in furrows; *Rice*: Abdominal white.

Particulars of strains evolved by hybridization—cont.

Strain number. (1)	*Time of harvest or duration in days.* (2)	*Other particulars.* (3)
CO 25 Blast resistant Sirumani (culture 3912.)	185	This is a pure-breeding hybrid extracted from the cross between CO 4 (*Gobi Anaikomban*) a Pricularia-resistant strain and ADT. 10 (*Korangu samba*) a highly susceptible strain. The plant is robust in growth with light tip grain. It yields 49 per cent higher than the control ADT. 10 or ADT. 11 in the average of seven years trials conducted in several places. It has been found to do well on Palghat taluk under tanks, where CO. 8 and CO. 12 are at present grown. It is of the same duration as Nellore samba. *Glume*: Straw with a very light reddish tip; *Colour of rice*: Translucent white; good quality; *Grain size*: L—7·1 mm.; B—3·0 mm.; T—2·1 mm.; Percentage of rice by weight 77; Vol. 60·0.
CO 26 Blast resistant Nellore samba (culture 3840).	195	This is another hybrid strain extracted from crosses between CO 4 and ADT. 10. The glume is dirty brown (similar to Nellore samba) with a purple tip. The plant is vigorous in early growth, yellowish in colour. It is a week later than ADT. 11. It yields 50 per cent higher than the control ADT. 10 Korangu samba in the average of seven years yield trials conducted at several places. *Glume*: Dirty brown; *Colour of rice*: White; good quality; *Grain size*: L—7·4 mm.; B—3·0 mm.; T—2·1 mm.; Percentage of rice by weight 77; Vol. 61·0.
Aduthurai—		
ADT. 8 Early White Sirumani (hybrid strain).	150	This is a hybrid strain from a cross between Molakolukulu and *White Sirumani*. Grown in all taluks of Tanjore, parts of Tiruchirappalli, North Arcot and Palghat taluk of Malabar. Exported to Ceylon market as par-boiled rice. Gives 8 per cent increased yield over *White Sirumani*. Average acre yield 2,800 lb. *N.B.*—Grown as a *Thaladi* crop it matures in 140 days and yields 2,300 lb. per acre. *Grain size*: L—7·2 mm.; B—2·9 mm.; T—2·0 mm.; *Glume colour*: Straw; *Rice*: White.
ADT. 20 Hybrid kuruvai.	105	This has been obtained from a cross between ADT. 3 *Kuruvai* and *White Sirumani*. It is valued both for its earliness and round shape of grain and is very popular with the ryots. It fetches a premium of four annas per bag. Gives an increased yield of 25·2 per cent over ryots' bulk. An average yield of 4,200 lb. per acre is recorded. *Grain size*: L—5·9 mm.; B—2·9 mm.; T—1·8 mm.; *Glume colour*: Straw; *Rice*: White.

Chemical treatment.—Colchicine treatment of germinating paddy seeds showed that 0·1 per cent for 24 hours was the optimum concentration for inducing tetraploids in rice. Most of such tetraploids were however completely sterile and further work is being carried out on them at present. Inducing genetic variability by means of acenaphthene was another method that was tried in rice. Sprouted seeds of GEB. 24 were treated with acenaphthene and kept at 10°C for 60 hours. Similarly, the seed of CO. 13 was treated with acenaphthene after soaking in pyrene. One mutant which was a week later than the parent was discovered and it gave up to 30 per cent higher yield. Further work is in progress. In GEB. 24, three mutants were discovered: one a short duration type, which was taller and better in tillering than GEB 24 untreated plants, and the other two later than GEB. 24, taller and better tillered, but segregating for a variety of grain sizes. Further work is in progress on these mutants.

A list of mutant selections and varieties successfully introduced is given in pages 44 and 45.

Other studies.—As mentioned earlier, a great deal of fundamental knowledge connected with rice has been gathered by various workers in the Paddy Section and also on the inheritance of characters in rice. A brief account of this work is given below.

Evaluation of strains.

Strain number and name of variety.	*Duration (sowing to ripening) in days.*	*Other particulars.*
Introduction—		
S.R. 26-B	150	A salt-resistant variety from Orissa—introduced in 1940 and successfully grown in Krishna and Godavari districts.
Kasipichodi No. 354	110	Introduced from Hyderabad and popular in uplands and deltas of Godavari district. A selection SLO. 16 is obtained from this.
T. 672	150	Introduced from Bengal variety called '*Patna variety*.' Does well in the Bhavani irrigated area.
Mutations—		
Coimbatore—		
GEB. 24 Kichili samba.	Second week of December.	Isolated from *Konamani*, probably a mutant. It yields best under early planted conditions and where the drainage is perfect and high manuring is practised. Its non-shedding habit, fine quality of rice comparatively higher proportion of rice to paddy by weight and its tolerance to inadequate water-supply and somewhat saline conditions have commended themselves to ryots throughout the State. It is largely grown in the delta areas in the Circars and Madurai as a first crop and as a second crop after '*Kar*.' It has given a maximum yield of 5,000 lb. per acre. It is the only a variety grown in the Hospet taluk of Bellary. *Grain size* L—7·8 mm.; B—2·[illegible] mm.; T—1·8 mm: *Glume colour*: Straw; *Rice*: White.
No 5782 Dwarf mutant.	150	A 'Dwarf mutant' induced by X-raying of germinating seeds of GEB. 24; shorter growing than GEB. 24 has profuse tillering and does not lodge even under heavy manuring. Grain size slightly shorter than GEB. 24 growing popular in Anantapur and Bellary districts.
Aduthurai—		
ADT. 15 Senkuruvai (mutant from ADT. 4).	110	Sowing time June for 'Early Kar season (Autumn-Spring rice). This has been obtained as a mutant from ADT. 4 (*Kuruvai*). Grown in Tanjore, Pattukkottai and parts of Tiruchirappalli, Chingleput, South Arcot and Salem districts. Gives an increased yield of 25 per cent over ryots' bulk. *Grain size*: L—7·6 mm.; B—2·9 mm.; T—2·0 mm.; *Glume colour*: Dirty in furrows; *Rice*: White.

Anakapalle—			
AKP. 13 ..	..	....	A mutant from AKP. 8 (*Maharaja bhogam*) selected in 1947. It is earlier than AKP. 8 and the yield is on a par with MTU. 9 (*Garikasannavari*) and 16 per cent more than *Kasipichodi*.
Maruteru—			
MTU. 20	Punasa Basangi (early mutant from MTU. 3).	First week of October ..	It is selected as a mutant from MTU. 3 (*Basangi*) at the Agricultural Research Station, Maruteru, which is fifteen days earlier than the parent strain. It is a vigorous growing type, does not lodge and comes to harvest before the cyclone months. It is finding favour with the higher delta ryots who grow pulses during the *pairu* season. *Glume colour* : Straw with purple tip ; *Grain size* : L—8·2 mm. ; B—2·7 mm. ; T—2·0 mm. ; *Rice* : White.

Anthesis.—In rice, anthesis or flower opening, commences shortly after the emergence of the panicle from the enclosing leaf sheath, starting from the spikelets at the tip of the panicle and proceeding in a succession of irregular waves to the spikelets at the base of the panicle. The maximum flowering occurs on the second day of panicle emergence and the whole process is completed in about a week. Ordinarily, the opening of the glumes in rice takes place between 10 a.m. and 12 noon, but in one wild species, *Oryza latifolia*, the glume opening was noted to be from 5 a.m. to 7 a.m. while in another species, *Oryza longistaminata* the spikelets open from 12 noon to 2 p.m.

Self-fertilization is the rule in rice and the percentage of natural crossing in ordinary varieties is quite small and varies from 0·1 to 2·7 per cent. But it is very high in some of the glutinous rices, going up to 10 per cent. With ordinary precautions, the risk of genetic contamination in rice due to " Vicinism " is very small indeed.

Artificial crossing.—The technique of crossing adopted by different workers in different countries is naturally different, but the one now in use at Coimbatore has been found to be quite satisfactory, being sufficiently simple and ensures a high percentage of setting. A panicle which is on the second or third day of blooming is first selected and after removing all the fertilized spikelets at the top, and the spikelets that may not open that day at the bottom, it is enclosed in a brown paper bag early in the morning. Due to the increase in temperature inside the bag, the glumes start opening much earlier in the day and since the anthers are not mature enough at the time, they come out and hang without dehiscing. These are caught hold of at the filaments by a pair of pointed forceps. When the pollen of the other parent is ready it is brought and dusted on to the stigmas of each spikelet and the whole panicle is kept enclosed in a cloth bag to prevent access to any foreign pollen.

Pollen Tube Studies.—The viability of rice pollen and its artificial germination was the subject of an investigation by one of the workers in the Paddy Section in 1941.

Rice pollen germinates on the stigma in about three minutes after pollination, and it takes about one hour for the pollen tube to enter the embryo sac. The migration of the pollen nuclei into the pollen tube occurs ten minutes after pollination. Rice pollen could be successfully preserved for a period of 24 hours at 12°C and 85 per cent humidity. The contents of the pollen were mostly carbohydrates and these stream out into the pollen tube on germination. The pollen showed the presence of enzymes like diastase, pectinase and cellulase, whereas the pistil showed the presence of pectinase only.

Receptivity of the stigmas in rice.—Four sets of crosses were made and utilized for studying the variations in stigma receptivity as measured by the percentage setting in spikelets that were first emasculated and then pollinated at different intervals, from the

same day up to seven days later. The main result of the study was that rice stigmas maintain their normal receptivity up to three days after the natural opening of the glumes, but decline in receptivity afterwards, until the seventh day when it is completely lost. This is helpful to the rice breeder in that when two parental types differ in flowering duration by not more than a week, cross pollination may be effected betwen them by bagging the emasculated spikelets of the earlier variety and pollinating them with the latter variety within six days after emasculation, although the percentage of grains is apt to be rather low. Again, if unfavourable weather sets in soon after emasculation of spikelets to prevent immediate cross pollination, it can be safely postponed for two or three days, with the certainty of securing the same degree of grain-set as by pollinating on the same day of emasculation.

Root studies.—Though rice flourishes under aquatic conditions, its root system is not of the acquatic type, but requires as much aeration as any non-aquatic plant. The roots are of two kinds, one long grown and much-branched and the other short, white and unbranched, and are arranged in close set rings emerging below the nodes. When seedlings are pulled out for planting, most of the roots get torn off, but a fresh set of roots is soon put forth. In fact it has been found that where the seedlings are kept with a limited supply of water in the nursery their root development is poor but such plants, when planted in a well-manured field with plenty of water, strike root much quicker than bigger seedlings raised with liberal watering.

The variations in root system are as wide as those observed in the aerial portions of the rice plant like shoots and panicles. Root development is also influenced to a high degree by the cultural practices that are followed. For example, in a broadcast crop, the rooting zone is confined to a few inches near the surface, as the seed is only at the surface, whereas in a transplanted crop the seedlings are thrust inside the mud and the rooting zone also is correspondingly deeper, as a result of which a planted crop is always more resistant to lodging than a broadcast crop.

Between varieties, root development is generally more extensive in last varieties as compared to short-duration varieties. Variations also seem to depend on whether a variety is an upland type or a low land type, whether it is a coarse grained variety or a fine one and whether the straw is stiff or weak. Root development is also influenced by soil types. It is greater in clay soils than in sands or loams. The drainage too has a close relation to root development; where it is too free, the roots do not get sufficient oxygen and hence remain poor. Strain GEB 24 is outstanding in its root development also and has a more profuse root system than any other variety of similar duration. Taller varieties have, as a rule, a greater downward as well as lateral spread in their root systems. There is also a definite correlation between tillering capacity and root development—the greater the tillering, the greater being the root system as well.

Root development in the rice plant is also affected by manuring practices; nitrogenous fertilisers like ammonium sulphate promote, while phosphatic and potassic fertilisers, tend to depress root growth. The maximum root development is obtained with application of bulky organic manures like green leaf, oilcakes or cattle manure.

Experiments at Coimbatore have shown that paddy plants do not suffer any set-back in growth even when all the roots were pruned off before planting the seedlings.

Developmental studies.—Tillering marks an important phase in the development of cereals and particularly in rice. Tillering in rice commences about two weeks after transplanting and continues in full vigour for three to five weeks after, depending on the duration of the variety. After reaching a maximum there is a decline in tillering due to the death of the late and ill-developed tillers. The critical period of tillering, i.e., the stage at which productive tillers are formed in sufficient numbers to contribute towards final yield, is two to three weeks before the maximum tillering phase. Since tillering is useful only if it results in increased yields, any tiller that does not produce an earhead is only a waste of plant food and energy, and all agronomic practices must be so adjusted as to encourage the rate of tiller formation as much as possible up to the critical period of tillering.

Under normal field conditions the proportion of productive tillers to the total number of tillers is more or less constant, irrespective of the number of tillers produced; but this proportion is a varietal character being low in long-duration varieties. The mean yield per ear and the weight of grain from the different types of tillers are also constant. Hence it follows that any increase in the mean number of tillers per plant or per unit area helps to increase the yield of grain per plant perunit area, and to obtain maximum yields the plant must be given optimum conditions for vigorous growth in the vital early stages, so as to produce a large number of productive tillers before the critical period.

Ear development.—The interval between the completion of tillering and commencement of ear formation seems to depend on the duration of the variety, being longer in long-duration types. In the case of early varieties and in late-planted crops, ear formation commences even before tillering is completed. The interval between tillering and ear formation is important in deciding upon the best time for applying a quick acting fertiliser like ammonium sulphate to the crop. In late varieties like CO 4 and CO 8, of over six months duration, the interval between the completion of the tillering phase and the commencement of the ear formation is over six months' duration, the interval between the completion of

Storage of grain.—At the time of harvest, there is usually about 15 per cent of moisture in the grain. This goes down to 10 to 12 per cent when the produce is stored in ordinary gunny bags, and the grain, though not very good for seed purposes, is found to keep well. But the same grain gets mouldy if stored in closed

metal bins because the moisture cannot escape into the atmosphere. Hence whatever may be the method of storage that is adopted, it is imperative to bring down the moisture to 10 per cent or less by adequate drying, before the grain is stored.

Resting period.—Germination tests conducted at monthly intervals at Coimbatore with GEB 24 seed showed that the viability remains unimpaired for 13 months after harvest. Afterwards there is a steady decline in viability, down to 80 per cent after 24 months' storage. This figure was maintained until 33 months had elasped from harvest time. Another strain CO 1 was good for 15 months but thereafter dropped to 49 per cent in 24 months' time. CO 2 and CO 3 declined in viability after 12 months of storage and showed only 24 per cent germination at the end of 24 months. Thus a wide range of variation is found to exist among paddy varieties in their retention of germination capacity. Generally it is observed that the seed that germinates readily after hearvest without a resting period loses its viability sooner.

Rate of germination.—It has been observed that while some varieties complete their germination within two or three days, others drag on for nearly a week, GEB 24, for instance, being markedly slower in germination than others. Apart from other morphological differences, this variation is apparently influenced by the thickness of the husk or glumes. Slow and "spread out" germination as well as seed dormancy is a wild character and on many of the wild rices at the Paddy Breeding Station, the germination is observed to be slow and protracted. The seed of some wild varieties is capable of remaining dormant in the soil for as long as a year. Delayed or defective germination is met with not only in old seed but also in fresh seed that has been stored in a defective manner, exposed to wet weather. One method of overcoming this difficulty of delayed germination is to give the seed a longer period of soaking in water before sowing.

Ratooning in rice.—Ratooning ability is essentially a varietal character. Certain varieties are capable of giving a secondary crop when harvested just at the time the grain is ripening and when the straw is still somewhat green. In certain limited areas near Chingleput where rice is grown under tank irrigation the crop is harvested by December, the field weeded and irrigated, when the stubbles shoot up and give a second crop. A special variety known as *Uthiri Kar* is grown for this and is claimed to yield under favourable conditions as much as the plant crop itself.

Observations made at Coimbatore on this ratooning in rice have shown that the grain size, duration, plant height and grain setting were all less in a ratoon than in the main crop. The viability of seed alone was equal in both. The reduction in size of grain is sometimes an advantage as a coarse grained variety becomes more acceptable thereby but as a general practice ratooning is not to be advocated as an economic proposition.

Starch and protein formation in the rice grain.—Starch is present in large amounts in the early stages of the ovary development in the pericarp layers nad ovary walls. This gets exhausted as the grain develops. After anthesis, starch becomes evident in the endosperm about four days after in cultivated varieties, and six days after in wild rices. In both wild and cultivated rices starch is noticeable in the embryo on the seventh day after anthesis, but whereas the starch gets exhausted in 15 days in the wild varieties, it persists till the 20th day in cultivated ones. In glutinous rices, starch is deposited only on the ovary wall, the carbohydrate in the endosperm and embryo being in the form of dextrin.

Traces of proteins are detectable in the ovary wall up to the fifth or sixth day after anthesis. These however disappear after the development of the aleurone and starch cells. One or two layers of the endosperm adjacent to the aleurone are rich in proteins. In the rice embryo tyrosine is the main amino-acid of the protein. It was observed that the aleurone develops earlier in short duration varieties than in the late varieties. Coloured rices appear to have thicker aleurone than white rices, and aleurone thickness seems to depend to a large extent on the coarseness of the grain. Aleurone development is at its maximum in the purple rices and in the glutinous types, while the poorest development is found in wild rices. Manurial experiments carried out on the same variety at four centres have indicated that green leaf was conducive to the greatest aleurone development, sodium nitrate was the next best, while aleurone thickness was the poorest in the plot, that did not receive any manure.

Tests for shelled and polished rice.—(1) A five per cent solution of caustic soda was run over shelled, once-polished, and twice-polished rice. In shelled rice a good yellow develops whereas in the polished rice, the reaction is a light yellow coloration accompanied with gelatinous emulsification. (2) Iodine solution at 0·05 per cent concentration is run over the samples for two minutes in a watch glass. The polished rice gets a deeper and quicker blue since the starch layers are exposed while the shelled rice remains only brown.

Cytogenetics in rice.—All cultivated varieties of *Oryza sativa* have a somatic chromosome number of 2n = 24. The other cultivated species of *Oryza*, *O.glaberrima* has also the same number. Apart from these two species, there are two more species, *O. Stapfi* and *O. grandiglumis* with the same number of 2n = 24 chromosomes, and with grains resembling *Oryza sativa*. A number of other species of *Oryza* have also been studied at the Coimbatore Paddy Station, namely, *O. latifolia*, *O. coarctata and O. eichengeri* with 2n = 48 chromosomes, and *O. officinalis*, *O. perennis* (synonymons with *O. longistaminata*, *O. barthii*) with 2n = 24 chromosomes. It is now agreed, on the basis of data gathered by various workers in this field, that in the genus *Oryza*, the diploid number is 24 and the tetraploid number is 48. Only the diploid species are economically important and no aneuploid species is known. (Plate 11.)

Plate 11.—*Two species of wild rice.* P. 61

A = *Oryza latifolia.* *B* = *Oryza eichengeri.*

At the Coimbatore Paddy Station, varieties of *Oryza sativa* have been isolated with haploid, triploid, tetraploid and aneuploid chromosome complements. In the aneuploid series, nullisomics with one or two deficient chromosomes as well as polysomic forms were isolated. Of these only the tetraploid forms are of any potential economic importance, the others having only an academic value. The first tetraploid to be obtained in the Paddy Section at Coimbatore was an auto-tetraploid from the strain GEB 24 and this proved to be a stable form, breeding true for tetraploidy. The changed features in this polyploid were increase in grain size, reduction in fertility and in tillering capacity. Other heritable features were not altered markedly. A detailed study of this auto-tetraploid led to the conclusion that from an economic point of view, allo-tetraploids and amphidiploids were more likely to be useful than auto-tetraploids.

Another cytogenetic study of rice at Coimbatore was that on inter-specfic crosses. As far as is known, all forms of *Oryza sativa* can be intercrossed, with no barriers of incompatibility. Besides, *Oryza sativa* has been crossed successfully with *O. glaberrima*, *O. perennis*, *O. officinalis* and *O. eichengeri*. Other combinations were tried, as in *O. latifolia* x *O. officinalis*, *O. perennis* x *O. eichengeri*, *O. eichengeri* x *O. latifolia*, but without success. It cannot be said, however, that these combinations are totally incompatible as the environmental factors that are conducive to seed setting are numerous and it is possible that persistent attempts under a different set of environmental factors might prove successful. For example the cross *O. sativa* (GEB 24) x *O. perennis* was accomplished after a large number of failures. Another cross between *O. sativa* variety (*Sukhadas*) x *O. perennis* failed to set any seed even after repeated attempts. In Japan, the cross *O. sativa* x *O. minuta* was done successfully, this being perhaps the only interspecies cross recorded in rice from work abroad. An intergeneric cross between *O. sativa* and *Leersia hexandra* was attempted at Coimbatore but without success.

Analysis of these crosses, *O. sativa* x *O. glaberrima* and *O. sativa* x *O. perennis* gave fertile progeny with segregation of characters in the second and subsequent generations. *O. sativa* x *O. eichengeri* was completely sterile. *O. sativa* x *O. officinalis* gave a sterile hybrid which was again crossed with *O. eichengeri*, giving a sterile interspecific hybrid. Among the *O. sativa* x *O. glaberrima* crosses, two Italian varieties of *O. sativa* were crossed with *O. glaberrima* and gave completely sterile hybrids. In all such sterile hybrids, the gametes fail to mature and to function normally pointing to the inference that lack of homology in chromosomes leads to failure of meiosis. Therefore speciation in Oryza has been accompanied by internal changes in chromosomes as well as by polyploidy.

There is another type of crosses where hybrids are sterile. When typical Indian rices called Indica types are crossed with

typical Japanese rices called Japonica types, the hybrids tend to be partially or totally sterile, according to the particular set of environmental conditions that exist at the time. Partial sterility was observed even when some Indian types were intercrossed among themselves. It is thus possible to divide a world collection of cultivated rices into different groups with varying grades of inter-fertility. This leads to the conclusion that in *Oryza sativa* itself, varietal differentiation has been accompanied by such chromosomal differentiation as may cause irregularities of meiosis in the hybrids. The original hypothesis that *O. sativa* could be split up into two sub-species—*japonica* and *indica* may have to be modified in the light of the enormous range of differentiation undergone by different rices in different parts of the world. The inference that structural differentiation in chromosomes has taken place within the species *O. sativa* thus appears to be a valid one.

Inheritance of characters.—Although the breeding of high yielding strains is the most important line of activity in any crop breeding station, the success of that work depends on an intimate and extensive knowledge of plant characters and their mode of inheritance. These characters naturally include not only the more apparent morphological characters but also the less evident ones that are concerned with the yields. On account of its vital importance, genetic study has been one of the major items in the work of the Paddy Breeding Station, ever since its inception. Numerous papers have also been published on the inheritance of characters in rice; these are listed elsewhere and a summary of the knowledge gained from these studies is given below :—

Inheritance of characters in rice.

Part of Plant.	Characters.	Nature of inheritance.
Any part of the plant .	Anthocyan in Pigment (Purple)	Two complementary genes necessary.
	Chlorophyll deficiencies.	
	Green : albino	3 : 1 and 15 : 1.
Leaf	Green : Small yellow green ..	3 : 1.
	Green : lutescent	3 : 1.
	Green : virescent : albino ..	9 : 3 : 4.
	Green : Xantha	3 : 1.
	Green : Yellow	3 : 1 and 15 : 1.
	Green : virescent	3 : 1.
	Green : zebra marked	3 : 1 and 15 : 1.
Leaf sheath	Purple lining : no lining ..	3 : 1.
Leaf axil	Purple : no colour	3 : 1 and 9 : 7 (closely linked with stigma colour).
Leaf blade	Purple colour : green	3 : 1; 9 : 7 and 27 : 37.
Leaf blade	Hairiness	Multiple (unpublished).
Auricle	Purple : not purple	3 : 1 and 9 : 7.
Junctura	Coloured : colourless	3 : 1 and 9 : 7.
Internode	Purple lining : colourless ..	3 : 1.
Spikelet arrangement ..	Clustering : intermediate : ordinary.	1 : 2 : 1.
	Loose : compact	3 : 1.
	Exsertion	Multiple (unpublished).

Part of plant.	Characters.	Nature of inheritance.
Glumes	Normal : double glume	3 : 1.
	Normal : inter : full double	1 : 2 : 1.
Colour of lemma and palea in the young stages.	Green : Gold	3 : 1. (The genes form a multiple series).
	Green : Dirty glumes	3 : 1.
	Pie-bald distribution : even	3 : 1.
	Dirty brown : gold	3 : 1.
	Mottling : Intermediate : even dirty (colour inhibitor factor).	1 : 2 : 1.
Ripening colour	Black : Straw	9 : 7 and 3 : 1.
	Straw : Brown	3 : 1.
Stigma	Purple : no purple	3 : 1 or 9 : 7.
Pistil	Normal : Multiple	3 : 1.
Awns	Presence of awns : no awns	Multiple (unpublished).

Character.	Genes effect.	Ratio.
Sterility	Normal : barren sterile	3 : 1 (barren sterile one pair of chromosome deficient.
	Sterile : Male-sterile	3 : 1.
	Sterile : semi sterile	3 : 1.
Grain size	Short : long	3 : 1.
	Short : intermediate : long	1 : 2 : 1.
	Shedding	Multiple (unpublished).
	Small : normal	3 : 1.
	Round : Oval	3 : 1 and 9 : 7.
Endosperm	Starchy : glutinous	3 : 1.
Pericarp colour	Purple (full) : brown	9 : 7.
	Purple : Red : White	12 : 3 : 1.
	Purple : white	3 : 1.
	Red : white	3 : 1 and 15 : 1.
	Red : gold	3 : 1.
	Red : grey : white	9 : 3 : 4.
	Red : grey : brown	3 : 1.
	White : Gold	3 : 1.
Habit of plant	Erect : prostrate	3 : 1.
	Geotropic : Ageotropic	3 : 1.
	Erect : floating	15 : 1.
	Spreading : erect	3 : 1.
Plant stature	Short : tall	3 : 1 and also multiple.
	Normal : dwarf	3 : 1.
Flowering duration	Early : intermediate : late	1 : 2 : 1.
Blast resistance	Resistance : susceptibility	3 : 1 (not definite).
Scent	Non-scented : scented	3 : 1.
Lodging	Lodging : Non-Lodging	3 : 1.

Variegation.—Plant variegation was found to be a character that is heritable only through the female parent, the male parent having no effect in the inheritance of this character. The irregular segregation ratios obtained and the non-random distribution of the different kinds of seedlings obtained from grain gathered from different tillers on the same parent plant indicate that the plastids rather than the nucleus are the organs concerned in the inheritance of this character in rice.

Agronomic experiments.—In keeping with its vital importance as the main food crop of the State, a great deal of attention has been devoted even from the early days of the Agricultural Department to the various agronomic aspects of rice cultivation. A very

large number of experiments have been designed and carried out not only in the Paddy Breeding Station at Coimbatore but also in the various Agricultural Research Stations in the different rice-growing regions of the State. These are summarized in the following pages, under convenient sub-heads like, seasons, sowing, transplanting, irrigation, manuring and other cultural operations.

Effect of season on duration.—It is of course common knowledge that varieties of rice that are suitable for one tract or season are always suitable for a different tract or season. Apart from the final yield, the one feature that is very markedly affected by such changes is the duration of the life period. Some varieties become shorter in duration and others longer. Two broad groups may be recognised in rice, namely, those that are time-limited or "period-bound" and those that are season-bound. Period-bound varieties take more or less the same period from sowing to harvest within limits, irrespective of the time of the year they are sown or planted, whereas season-bound varieties come to flower and ripen only during a particular season, irrespective of when they are sown or planted. Most of the short duration *Kuruvai* varieties of Tanjore district, *Kar* variety of Tirunelveli, *Sornavari* of Chingleput and South Arcot, *Garikasannavari* of the Godavari delta, belong to the first group. A large number of short-duration varieties of three or four months' duration was tested at Coimbatore for this character and the majority of them were found to be period-bound, retaining their short duration even when grown out of their usual season, though there were a few varieties that did change their normal duration and ripened later. From the point of view of yield, such out-of-season sowings were usually poor.

As examples of season-bound varieties may be cited the *Kayama* rice of North Malabar which is usually sown in the nursery in April or May. When this was taken to East Coast and sown in the nursery in June or July, it ripened in the same season as on the West Coast, i.e., in September-October. In addition, while it never produces more than four or five tillers in Malabar, it formed eight or ten tillers in the East Coast. The *Konamani* of Godavari district is a five to six months crop, planted in June and harvested by October-November. When this variety was planted at Coimbatore in August-September, it became shorter in duration and ripened in four months. *Banku* is a variety of rice introduced into Madras from the Madhya Pradesh with a normal duration of four months. It gives good yields in two seasons when planted either in June-July or October-November. If however it is planted in March-April, its duration is very much lengthened and does not ripen till October, its normal ripening season, with planting in June-July.

In contrast to the above instances, there are several varieties that have proved quite satisfactory when moved from one tract to another. Thus the *Nellore Samba* was first introduced into Tanjore from Nellore district where it grew so well that it has now

spread over most of the other Tamil districts. *Poombalai* or *Karthiga Samba* is a variety of Tirunelveli district, which in its improved form as strain CO 2 of the Paddy section, has now become quite a popular variety in the North and South Arcot districts and in Chingleput, Tanjore and Tiruchirappalli districts as well.

Among the strains evolved by the Department of Agriculture, Madras, GEB 24 is a notable example of season-bound rice. This strain is a five months variety in Coimbatore when planted in July-August and is very popular in the State on account of its good yield under varied conditions and high quality of table rice. In the Godavari delta, it takes six months to mature as the planting time there, is earlier in June-July, and comes to harvest at the same month as at Coimbatore. In Malabar, it was a failure as a first crop planted in May-June, as it remained without ripening long after the local varieties were all harvested and thus became subject to severe damage by insect pests. It has, however, fitted in as a second crop for West Coast conditions, planted in October and harvested in January. It is also planted in December in Madurai and harvested in March-April. Two other strains evolved at Coimbatore, viz., CO 2 and CO 3 are also similar and have fitted in the second-crop season in South Kanara from October to January.

Experiments were conducted from 1925 to 1929 at Coimbatore and Aduthurai to study the effect of planting rice varieties at different times of the year. At Coimbatore, the strains GEB 24 and CO 2 were sown at monthly intervals from June onwards and transplanted later under uniform conditions, up to next February. GEB 24 was found to give normal yields when sown in any of the months July to September. Yields from October and November sowings were rather variable and uncertain. The November sowings, in particular, gave average yields in some years and poor yields in others. There was however a definite drop in yields from all sowings later than November. January sowings gave the poorest yields, while with February sowings the yields were poor in general though good in some years, but the duration was so prolonged that the practice was not worthwhile. The flowering too was observed to get progressively earlier with sowings from June onwards reaching the limit in January and thereafter getting delayed.

Strain CO 3.—In this variety, the results were somewhat different. Early sowings in July-August gave high yields, but September sowings gave poor yields. October and November sowings gave poorer yields, but there was a slight improvement with December sowing while January and February sowings gave the poorest yields. As regards the flowering duration there was a regular shortening up to October sowing and then a lengthening, the February sowing being the most abnormal in flowering duration.

Grain setting was generally poorer with late sowings, but in evaluating the factors conducive to poor yields the high incidence of insect pests in all crops grown out of season must also be taken into account. On the whole these experiments showed that for securing satisfactory yields under Coimbatore conditions the strain GEB 24 should not be sown later than September, whereas CO 3 should be sown as early in the season as possible to get the maximum outturn. It may also be said in general that for getting good yields in rice, the sowings should be done early in the season. This applies equally to both short duration and long duration types. While cultural practices like liberal manuring and closer planting of seedlings might help to mitigate the effect of late sowing, they can never replace the advantages of early sowing.

Sowing practices—Relation between seed rate and survival of seedlings in the nursery.—Experiments were conducted at Aduthurai in 1931–32 to see if seedlings from thicker sown seed beds were more prone to die off on transplanting than those from thin-sown seed beds, but no marked difference was noticeable in the percentage of survival in the two treatments.

Seed rate in nursery.—At the Samalkota Agricultural Research Station, a seed rate of 30 " Kunchams " (180 pounds) per acre of nursery was found to yield 57 per cent more than in the local practice of 100 " Kunchams " seed rate equivalent to 600 pounds per acre. At Palur (South Arcot district) a seed rate of 2½ lb. per one cent of nursery area was found to be the best. At Buchireddipalem (Nellore district) increased yields were secured by planting seedlings from a thin-sown nursery at 20 lb. per acre than from a thicker sown nursery of more than 30 lb. per acre. Experiments at Maruteru (West Godavari district) with nursery seed rates of 1¼, 2½, 5 and 7 pounds of seed per cent, in both manured and unmanured nurseries, showed that seedlings from a manured nursery gave better yields than unmanured. When the seed bed is not manured thinner sowings gave higher yields than thicker sowings. Thin-sown seedlings in a manured seed bed develop nodes earlier than in unmanured seed beds and hence should be planted out at the correct age, but whether manured or unmanured thin-sowing in the nursery is always to be preferred as advantageous.

Experiments at Aduthurai have shown that there is no difference either in germination or in ultimate yields between well-filled and badly filled paddy seed.

Dry and wet nurseries.—The relative merits of wet and dry seed beds were compared for three seasons at the Paddy Breeding Station, Coimbatore, with two varieties GEB 24 and CO 3. The results showed that there was no appreciable difference between seedlings from the two kinds of nurseries, but a similar experiment at Aduthurai, with three varieties, gave results in favour of dry nurseries, in all the three varieties tried. At Pattambi (South

Malabar) a similar experiment during the first crop season did not show any difference between the two types of nurseries. At Pattukkottai (Tanjore district) seedlings from wet nurseries were found to be better than those from dry nurseries in the case of short-duration varieties. For long-duration varieties the results were inconclusive in the trials conducted from 1945 to 1947.

Type of seedlings.—To see whether the nature of the seedlings at planting time would affect the subsequent yield, an experiment was carried out at Coimbatore in 1941–42 planting strong and tillered, strong but not tillered, and weak seedlings and the results showed that the conditions of the seedlings at planting time did have an effect on the final performance, the healthier seedlings giving always the higher yields.

Age of seedlings.—The period for which rice seedlings can stand in the nursery without detriment depends upon a number of factors, such as the fertility of the seed bed, the manner of preparing it and the nature of the variety that is sown in the seed bed. The general accepted rule is that for short-duration varieties, the period in the nursery should be short, whereas for long-duration varieties it could be longer. One week is allowed in wet nurseries for every month of duration of the planted crop. In the case of dry nurseries, however, this period could be longer and the seedlings might be left in the nurseries longer than the safe limit in wet nurseries. In addition to age, the condition of the seedlings is also another point for planting out, because, more than mere age, it is the commencement of node formation that makes the seedlings unfit for planting. So long as there is sufficient room for plants to put forth tillers without forming nodes, the age of seedlings does not affect the crop. In all short-duration varieties of less than four months, the seedlings can be transplanted even earlier than three weeks, provided they are well grown. Experiments with different ages of seedlings ranging from 25 to 70 days have shown, at Coimbatore, that in the case of crops with a duration of five months or less, there was no difference in yield by planting seedlings of different ages. When seedlings of different ages were planted on the same date, there was no difference in the flowering period, but when the planting was done on different dates, the earlier the planting the earlier was the flowering. It was also noted (in the Central Farm, Coimbatore), that with a five and half months' variety, there was no difference in yield between seedlings of different ages from 25 to 40 days, when such seedlings were from a thick sown seed bed. When the seed-beds were sown thin, then the younger seedlings gave better yields than older ones.

At Berhampur (now in Orissa State) trials with a five-months' crop, *Bayyahunda* showed no significant difference in yield between seedlings of 30, 40 and 50 days of age, but the yields diminished with seedlings beyond 50 days. At Pattambi it was noted that

when transplanting was done in the normal season it did not matter if the seedlings were even 60 days old. But where the transplanting gets delayed beyond the normal season, the seedlings should not be more than a month old.

At Aduthurai, a period of one week in the nursery for every month of duration of the variety from sowing to harvest, was the optimum. At Ambasamudram (Tirunelveli district) it was observed in the case of CO 8 *Anaikomban* that seedlings from seed beds sown early in the season could be planted up to 66 days without reduction in yield, but seedlings from late-sown seed beds gave always poorer yields irrespective of their age at planting time. Experiments on similar lines at Palur in South Arcot district, showed that there was no difference in yields from seedlings aged 30, 40 and 60 days when planted. At Buchireddipalem in the Nellore district 60 days seem to be the optimum and seedlings aged more than two months gave poorer yields. At Samalkota for the variety *Konamani*, 25 days-old seedlings gave better yields than 35 and 40 days-old ones. The planting experiments on this station also showed that earlier plantings yielded more than late plantings. Neither thick planting nor manuring could help to step up the yields in late season planting. Short duration varieties suffered more than long-duration ones by late planting.

The general conclusion that can be drawn from all these experiments is that it is advisable to transplant the seedlings as early as possible on the basis of one week in the nursery for one month of duration of the crop. Where some delay is unavoidable, however, there would be no great harm in keeping the seedlings up to 60 days in the nursery provided they do not form nodes by then.

Broadcasting and dibbling.—Experiments at Pattambi during the first crop season did not show any difference in yield between broadcasting and dibbling the paddy seed. At Ambasamudram dibbling gave as much yield as transplanting though it was very much costlier and needed six times the labour as transplanting. Broadcasting needed very little labour but gave lower yields than transplanting or dibbling. At Buchireddipalem, dibbling paddy seed that was smeared with cowdung gave a well established crop earlier than transplanting. In yield it was on a par with transplanting but was significantly better than a broadcast crop.

Planting.—In rice cultivation transplanting is the normal practice. Nearly four-fifths of the rice grown all over the world is transplanted, and in practically all countries where high yields of rice are recorded, as in Spain, Italy and Japan, transplanting is the rule and broadcasting the exception. Broadcasting of rice is confined to tracts where the season is not definite and the water-supply uncertain. Drilling the crop is reported to be replacing, as in California, the practice of transplanting rice owing to labour

shortage. In Italy where too, the labour is costly attempts are being made to design a transplanting machine which would work satisfactorily under puddled conditions. The fact remains, however, that although the advantages of transplanting are sufficiently recognised wherever rice is cultivated, no satisfactory reason has been found so far to explain exactly how or why transplanting is superior to other methods of growing rice.

A number of experiments have been carried at various research stations on this question and they are summarized below.

At Berhampur Rice Research Station, it was noted that in good seasons broadcast crops yielded as much as transplanted crops, but in actual practice weather and seasons are so uncertain that an ideal broadcast crop is seldom met with. At Coimbatore experiments with varieties of different durations showed that transplanted crops gave better yields than broadcast crops. At Pattambi no difference was found in the yields of short duration varieties between broadcasting and transplanting but with long duration varieties transplanting gave better yields. At Pattukkottai, trials with *Samba* rice from 1939 to 1942 have shown that transplanting was definitely superior to broadcasting.

'Topping' seedlings before planting.—There is a practice of cutting off a portion of the leaves at planting time when the seedlings are a bit rank and overgrown. Experiments at Aduthurai have shown that topping of seedlings at planting time was harmful for short duration *kuruvai* types but had no effect on the long duration *samba* types. Similar trials at the same station on root pruning in 1933 to 1936 have shown that such pruned seedlings take a longer time to get established after planting and the yield also is considerably depressed. Experiments made here between 1926–1929 on bunch versus single planting showed that there was no difference between the yields from seedlings planted in singles, doubles or triples, while bunch planting merely meant so much loss of valuable seedlings that could be used for planting a larger area.

Spacing.—An experiment on spacing was continued for eight years in succession at the Central Farm, Coimbatore, with two local varieties, *Sadaisamba* and *Chinnasamba*, the former being coarser grained and earlier by a fortnight than the latter. The spacings compared were, singles at four, six and nine inches, doubles at nine inches, and trebles at nine inches and 12 inches against the local method of close planting in bunches. The results indicated that with *Sadaisamba* in no case was any of the spacings definitely better than the local method of planting, in grain yield except trebles at 12 inches spacing. The straw yield was definitely poorer than the locals in all the plantings.

A number of studies made on this aspect have indicated that spacing has a greater influence on the number of tillers developed

and the size of the earhead than the number of seedlings per hole. In short-duration varieties, it is the total number of seedlings planted per unit area that influences the total yield rather than the number of tillers or the size of earheads. For a given area the same number of plants may be planted in two ways, either by increasing the number of plants per hole and the space between holes or by reducing the space between holes and reducing the number of plants per hole. The results of various spacing trials show that for early varieties it is better to reduce the number of seedlings per hole and plant them closer. The spacing that is best for a particular area must be determined only by trial and no serious attention need be paid to the exact number of seedlings per hole, although the fewer they are the better. Thus at Aduthurai experiments from 1941 to 1944 have shown that for *Kuruvai* a three-inch spacing with two seedlings per hole was the optimum while for *Thaladi*, a six-inch spacing with two-three seedlings per hole gave the highest yield. For *Samba* a spacing of 6 inches by 6 inches or 6 inches by 12 inches were the best. The fewer the number of seedlings per hole, the better were the yields. At Pattambi, the optimum spacing was six inches between clumps. When the spacing was wider, more seedlings were required per clump to give the same yield. Extra wide spacings of 18 inches and over were definitely uneconomic. At Ambasamudram, a 4 inches by 4 inches spacing gave the best yield in the first crop (*Kar*) irrespective of the number of seedlings that were planted in each hole, while 6 inches by 6 inches was the second best. For the second crop in this tract (*Pishanam*) the best spacing was 6 inches by 6 inches. At Palur planting six inches apart with one or two seedlings in each hole gave better yields than planting them in bunches of ten or more seedlings. At Maruteru, a wide spacing up to 12 inches with four seedlings per hole was advantageous for the main crop during periods of labour scarcity, but where cost of labour was not a deciding factor a closer spacing of six-seven inches with fewer seedlings per hole was the best. In poorer soils closer planting is always advisable. At Samalkota, single seedlings planted six inches apart gave the highest yields, and even manuring did not compensate for the reduction of population in wider spacing. At Buchireddipalem, close planting with an upper limit of eight inches and up to three seedlings per hole gave the best yields. With wider spacings and a larger or smaller number of seedlings per hole, the yields were poorer.

Spacing and manuring.—A comprehensive experiment was conducted at the Paddy Breeding Station in 1933–35 with six spacings, and two varieties of five and six months' duration with and without manuring. Manuring included 4,000 lb. of leaf. In the beginning only three spacings of three, six and 12 inches were adopted and the yield per unit area was found to be highest with the three-inch spacing. The six-inch spacing was only slightly lower in yield, but 12 inches spacing was definitely too wide.

Hence this 12-inch spacing was omitted and three more intermediate spacings of $4\frac{1}{2}$, $7\frac{1}{2}$ and 9 inches were included and the experiment continued for two more seasons.

The general trend of the results was that the optimum spacing for a five months' variety was $4\frac{1}{2}$ to 6 inches. For the six months' variety the best spacing was $4\frac{1}{2}$ inches. Both wider spacing and manuring increase yields by improving the number and size of ears, but the former had the greater effect than manuring. There was no differential effect of the manure in the different spacings. One interesting feature was that although the average yields at Coimbatore were very much higher than the yields at Berhampur or Pattambi, the optimum spacing for long duration varieties was apparently the same, namely six inches, in all these centres. At Maruteru, however, the optimum spacing could be more than six inches, as the tillering was definitely better than at Coimbatore. Experiments at Pattambi have shown that with close spacing more than one seedling per hole reduced the yields, whereas with wider spacing, a larger number of seedlings per hole tended to improve the yields. The optimum spacing was 4 inches by 4 inches and the yields with all spacings tended to become equal both in manured and unmanured plots.

It would be clear from the results outlined above that it is not possible to lay down any definite rule about the optimum spacing for planting rice, as this would vary according to the variety used and the fertility of the soil. It can therefore be determined only by actual trials at the particular centre. While soil and varietal differences are clearly defined in relation to different spacings, the uniformity of the results obtained for different spacings, from year to year at various centres of experiment, would seem to indicate that the season has very little influence on the spacing effect.

Double transplanting.—In certain parts of the Northern Circars, where the water-supply is not sufficient to irrigate the entire area at the commencement of the planting season, there is a practice of first planting out the nursery seedlings very thickly in a small field and later of pulling them out and replanting them with the usual spacing in the usual fields after the receipt of full water-supply. There is a common belief that this system of double planting improves the yield, but experiments conducted for two seasons at Aduthurai failed to show any difference in yield between normal planting and this double planting. At Pattambi too, double planting of early sown nurseries of the second crop did not differ in yield from the single planted crop. At Pattukkottai, trials in 1942–44 showed that normal planting gave better yields than double planting. At Maruteru, when the nursery is sown early by the end of April, replanting after a month of the first planting (with MTU 1) gave better yields than single planting by the end of June, with early sown nurseries. With late sowings towards the end of May, there was no difference between single and double planted yields. At Buchireddipalem, it was found that double planting, namely,

30 days in the primary nursery and up to 70 days in the secondary nursery, was more economical than single planting due to the uncertain nature of the south-west monsoon in these parts.

Irrigation—Duty of water for rice.—The duty of water is the irrigation work which a given quantity of water can perform and is usually expressed as the number of acres of a crop that can be irrigated by a continuous flow of water at the rate of one cubic foot per second. The duty of water when used to grow a rice crop is usually less than when dry crops are grown under irrigation. The total quantity of water required by a rice crop grown under swamp conditions varies according to the duration of the variety grown, the soil on which it is grown and the nature of the irrigation whether canal, tank or wells. Experiments were conducted at the Paddy Breeding Station at Coimbatore for two seasons 1932 to 1934 to determine the total quantity of water required for a medium duration variety (*Vellaisamba* CO 3) ripening in 160 days. An average duty of 84·8 acre-inches of water was found necessary for this crop, including both irrigation and rainfall.

The quantity of water required by the same variety at different stages of growth is given below :—

Stage of crop.	Acre-inches (including irrigation and rainfall).
1 From preparation of plots to planting	25·63
2 From planting to flowering	48·27
3 From flowering to last irrigation	10·89
Total ..	84·79

Effect of varying quantities of water and intervals of irrigation.—An experiment was conducted for five years at the Paddy Breeding Station, Coimbatore, with the following treatments, two inches of irrigation at intervals of three, six and nine days, four inches at six, 12 and 18 days, 'normal' irrigation (i.e., as and when required by the look of the crop) during the first month and then four inches at 12-day intervals, and 'normal' irrigation throughout the life of the crop as control. It was observed that in years when the rainfall was normal or above normal none of these various treatments was significantly different from the control, but when the rainfall was below normal, irrigation at the rate of two inches in three-day intervals or four inches at six-day intervals both working out to a duty of 40, gave the best yields. However it may be mentioned that the underground seepage was a disturbing factor and it was concluded that for irrigation experiments small plots are not suitable.

Effect of intermittent drying and irrigation on the yield of rice.—Five treatments as given below were tried in this experiment which was carried out from 1946 to 1949 on ryots' fields near Mettupalayam in connection with investigation on malaria control :—

(1) Water to stand in the field for four days continuously, followed by two days' drying.

(2) Water to stand for four days, followed by three days' drying.

(3) Water to stand for four days, followed by four days' drying.

(4) Water to stand for four days, followed by five days' drying.

(5) *Control.*—Water to stand continuously as practised by ryots.

The results showed that the ryots' practice was the best as it gave higher yields than all the other treatments both in grain and straw.

Garden and wet cultivation of rice.—Two varieties, *Kasipichodi* and *Thekkancheera* (PTB 10) were tried at Pattambi, both under wet land conditions and garden land conditions, to test the theory held in certain quarters that rice crops are best when raised as a garden land crop. The result proved beyond doubt that the wet system was the best for rice, as the yield obtained from the garden method was only a third of that in the wet method.

A fuller account of irrigation experiments conducted on rice will be found in the chapter on Irrigation.

Cultural Experiments—Ploughing.—Paddy soils, especially the heavier clayey types that are found in the deltaic areas, are generally left fallow after the harvest of paddy until the next season. When irrigation water becomes available, the fields are flooded till the land is well soaked and then ploughed. A series of experiments were conducted in the Agricultural Research Stations at Samalkota, Maruteru and Aduthurai to know if such lands could be prepared earlier by ploughing them soon after harvesting paddy. At Samalkota, the trials were conducted from 1911 to 1915 and showed that yields from fields that were ploughed or dug up in a dry condition in November were uniformly poorer by 10 to 30 per cent than from fields puddled in the usual manner. This reduction in yield could not also be corrected by subsequent applications of green leaf and bonemeal at puddling time. Dry ploughing during the *Tholakari* (hot weather) season with the help of the early pre-monsoon showers was also not beneficial.

In another experiment at the same station from 1909 to 1913, one portion was cultivated a number of times after the harvest of the rice crop and in the next season, was planted with rice without puddling and the yields compared with a similar field that was left undisturbed after the previous rice harvest and puddled later in the usual manner. Here too the results were uniformly in favour of puddling. The increase amounted in some seasons to as much as 50 per cent of the yields from non-puddled plots.

Similar experiments were continued in a modified form from 1928 till 1932, and in these there was an indication that the harmful effects of dry cultivation could be corrected to some extent by puddling the fields before planting rice.

At Aduthurai too, it was found that dry ploughing depressed yields by not less than 10 per cent in the first crop though the harmful effect disappeared in the following *samba* crop. On these soils the bad effect of dry ploughing could be remedied by applying green leaves at 4,000 lb. plus one hundred weight of superphosphate per acre, but even then the unmanured and puddled plots gave better yields than the dry ploughed and manured plots.

On lighter soils as in the sandy loams of Palur, ploughing the soil in summer did not result in any adverse effect on the succeeding rice crop. The harmful effect of dry ploughing heavy clay soils becomes evident only when rice is grown as a wet crop, but not when it is grown as a pure dry crop. This was proved by experiments at Samalkota by digging up in summer one portion in the dry land area and leaving it for weathering along with fallow plots left without digging. When dry rice was grown on these plots, it was found that the yields from dug plots was 25–35 per cent higher than in the fallow plots, a result that was just the opposite of what was found with wet land rice.

The second crop problem in the Godavari delta.—In the Godavari delta there is a long interval between the main crop (*sarwa*) harvested in October and the second (*dalwa*) crop that is planted in February. This interval could be profitably utilized to grow another rice crop as plenty of water is available in the canals for eleven months in the year from June to April, but for the fact that any crop planted earlier than February invariably fails on account of severe insect damage and poor growth due to adverse season. Fields that are planted late in February suffer from water shortage towards harvest time in May.

This problem of raising an intermediate crop between October and February has been under investigation at the Agricultural Research Station, Samalkota, for a number of years but no satisfactory solution has been found possible so far. Three main lines were explored in this investigation; one was to try a large number of short duration varieties in October to see if any of them would come up well in the winter months. None was found suitable or capable of withstanding the adverse seasonal conditions between November to January. A second line of study was to grow a short duration crop in the main crop season as done in the south in Tanjore and follow it with a long duration variety planted in November and harvested in February or March. This too was a failure as none of the short duration varieties tried was found suitable. A third alternative was to grow a broad cast crop in October on the strength of a common belief that a broadcast crop was less affected by stem borer. This too was not a success and the problem still remains an unsolved one, though in the present context of widespread food shortage a satisfactory solution would be very helpful.

Electro-culture experiments.—With a view to test the claims that were made from time to time regarding the increased yields

in crops obtained by "electro-cultural" methods of soaking seeds in water through which electric sparks had been passed, a series of experiments were conducted on rice at the Agricultural Research Stations at Pattambi, Aduthurai and Palur from 1939 to 1941 and lately at Tirurkuppam in 1945–47. At Pattambi the effects on growth and yield of rice of passing electric sparks on dry seed, on sprouted seeds and of soaking the seed in sparked water were tried, but in none of these was any effect evident. At Aduthurai the treatments tried were (1) soaking the seeds in sparked water before sprouting, (2) soaking the seed in sparked water and sparking the germinated seed again before sowing, and (3) sparking the water used for irrigating the planted field, but here again no difference was noticeable between these treatments and untreated controls in growth or yield. At Palur too, no increase in yield was obtained by sparking the seed or the irrigation water. At Tirurkuppam the experiments were conducted in a more comprehensive manner, testing the effect of sparking at different stages from the seedling to the adult stage.

The study of the effect of electro-culture on rice was taken up in the *sornavari* season—May to September—as this is the season when the number of rainy days and the wetness of soil are considerably less than in the other seasons.

Five one-cent beds for the treated nursery and five one-cent beds for the 'control' nursery, with interspace of 40 feet between the two nurseries to obviate the conduction of electric energy using a magneto from the 'treated' to the 'control' nursery, were prepared. On days of heavy rainfall when the whole plot was wet, sparking was not done. The seed-beds were manured with powdered groundnut cake at 500 lb. per acre. Seeds of CO 13 paddy were soaked in separate earthen containers kept over insulators. The seeds in five of the pots intended for sowing in 'treated' beds were sparked for two days and on the third day the seeds were sown. The treated seeds were sown after covering the hand with rubber gloves. The treated beds were sparked every day after irrigation. Germination and growth in the treated and control beds were similar. There was no difference in growth, colour and vigour of seedlings in either of the beds.

Planting was done (i) on a bulk scale in ten-cent plots, (ii) in replicated trials the 'treated' and 'control' beds being arranged in ABBA manner, and (iii) in cement tubs kept over insulators.

Ten cents in the middle of two adjacent plots were prepared for planting. The distance between the adjacent plots was over 80 feet and the distance between the irrigation channel and the plot was over 40 feet to obviate the conduction of electricity. Irrigation of the ten-cent plots was done by rubber hose pipes to prevent the water wetting the space between the channel and the plot.

'Treated' seedlings after they were pulled out were kept in trays placed over rubber sheet serving as insulators and sparked

prior to planting. The plot planted with 'treated' seedlings was sparked every day, except on days of heavy rainfall, until the crop did not require irrigation. Once in a way a copper wire connected to the magneto was drawn over the seedlings. The 'treated' and 'control' plots did not show any difference in growth. There was no difference in flowering either. The plots were harvested in the first week of October. The 'treated' plot gave less yield than the 'control' plot. The acre yields of grain and straw from the 'treated' and 'control' plots were 2,555 lb., 2,690 lb., 2,915 lb. and 3,455 lb. respectively.

For the replicated trial, 24 plots each measuring 20 feet by 10 feet were laid out in ABBA manner. As in the case of the bulk trial plots the distance between the sub-plots and the distance between the irrigation channel and the sub-plots was over 30 feet and the irrigation from the channel to the plots was done by rubber hose-pipes. Planting was done in doubles with seedlings spaced 6 inches by 6 inches apart. The 'treated' seedlings were sparked prior to planting and the treated beds were sparked everyday as in the bulk trial. There was no difference in the growth of seedlings in the 'treated' and 'control' plots. The difference in yield in respect of both grain and straw between the 'treated' and 'control' plots was not statistically significant.

Twelve tubs were planted with 'treated' seedlings and 12 with 'control' seedlings. The treated tubs were sparked every day after irrigation. Within two weeks after planting the treated seedlings were so badly affected by electro-culture that the treatment had to be stopped for ten days until the plants recovered. The sparking was then resumed and continued till the tubs did not require irrigation. The 'treated' plants came to flower three days later than the 'control' plants. The yield data show that 16·9 per cent increase in treated tubs in respect of grain yield is statistically significant while 8·9 per cent increase in straw yield is not statistically significant. From the results obtained it can be concluded that electro-culture on a field scale does not give increased yield either in grain or straw though it has some effect on plants grown in tubs mounted on insulators. As an aid to practical agriculture electro-culture is of doubtful value.

Manuring—(*Note.*—In the following discussion of the results of different manuring experiments on rice, nitrogen is referred to as 'N', phosphoric acid as P_2O_5 and potash as K_2O.)

Experiments conducted on the relative merits of manuring the seed bed, as against manuring of the planted fields at the Paddy Breeding Station, Coimbatore, and the Agricultural Research Stations at Pattambi, Aduthurai, Buchireddipalem and Maruteru have shown that manuring the nursery alone is not sufficient, as no effect is seen in the final yields of the planted crop even with heavy doses of manure in the nursery. For ensuring good yields, liberal manuring of the planted fields also is quite essential. (Plate 12.)

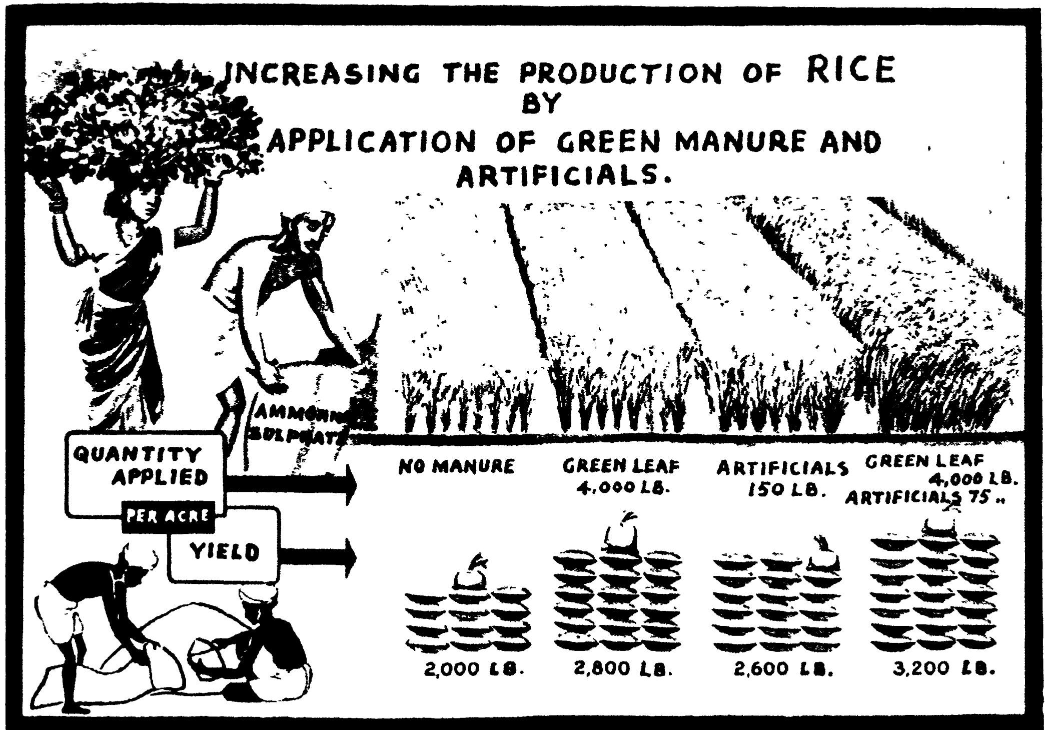


Plate 12 —Increasing rice yields by manuring P. 79

Effect of wood ash.—At the Pattambi Research Station, wood ash was applied to nurseries at different rates, of 1,000, lb., 2,000 lb., 3,000 lb. and 4,000 lb. per acre but no difference could be noticed between any of these in the final crop yields. Wood ash applied along with groundnut cake to the planted crop gave significantly higher yields than when applied alone, but wood ash plus green leaf manure was not profitable.

Green manuring—Central Farm, Coimbatore.—Trials with various levels of sunnhemp, ranging from 2,000 to 12,000 lb. per acre have shown that 4,000 lb. is the optimum dose for rice.

Pattambi.—Green leaf manure was applied in doses ranging from 2,000 to 10,000 lb. per acre and a progressive increase in yield was noted from 2,000 to 8,000 lb.

Pattukkottai.—Here too, green leaf manure was tried from 2,000 to 10,000 lb. per acre, in combination with bonemeal and 5,000 lb. per acre was found to be the optimum dose.

Palur.—Applications of 3,000 to 9,000 lb. per acre of *Daincha* were compared with no manure as the control. The optimum dose was found to be 6,000 lb. for the early (*Kar*) season and 9,000 lb per acre for the Samba season crop.

Trials with different kinds of green manures—Paddy Breeding Station, Coimbatore (1937–1940).—Three different green manure crops *Daincha, wild indigo* and *Sesbania speciosa* were tried in quantities to supply 15, 30 and 45 lb. of nitrogen per acre. The results of three years' trials did not show any difference between the different green manures tried. *Croton sparsiflorus*, a weed commonly found in all waste places, was also found to be a good green leaf manure.

Pattambi.—Leaves of mango, Vengai (*Pterocarpus marsupium Roxb*) and *Hyptis suaveaolens* were tried as green leaf manure for rice. There was no difference in yields.

Samalkota.—*Theegapesara*, *Sesbania speciosa* and *sunnhemp* were tried as green manure for four years. No difference was noticed between these in the subsequent yields of rice.

Palur.—There was not much difference in rice yields, due to different green manures such as, Daincha, sunnhemp, indigo, etc. Erukkam (*Calotropis*) gave higher yields than other green manures.

Comparison of cattle manure, green leaf and processed green leaf—Pattambi—There is no advantage in processing the green leaf (by using it as a bedding for cattle as is done in South Kanara) as green leaf manure as such is equal to and even better in higher doses than processed leaf.

Groundnut cake, green leaf and cattle manure—Pattambi.—Groundnut cake alone or in combination with other organic manures gave the highest yield, followed closely by green leaf.

Palur.—Green manure at 5,000 lb. per acre resulted in higher yield than cattle manure, groundnut haulms or oil cake.

Groundnut cake, green leaf, ammonium sulphate in different combinations—Aduthurai (1941–44).—A combination of 200 lb. of groundnut cake, 4,000 lb. green leaf and 100 lb. of ammonium sulphate gave the best yield in one year and 4,000 lb. green leaf plus 100 lb. of ammonium sulphate gave the best yield in another year.

Complex manurial experiment with green leaf, groundnut cake ammonium sulphate and super in different combinations—Aduthurai (1942–45).—Higher yields were obtained with higher doses of nitrogen, but sixty pounds of nitrogen in the form of groundnut cake and ammonium sulphate, in the proportion of 1 : 1, in combination with 60 lb. of phosphate, over a basal dressing of green manure, was found to be the best combination.

Green manure in combination with phosphatic manures—Anakapalle.—Experiments with 0 lb., 4,000 lb., 6,000 lb. and 8,000 lb. doses of green leaf, in combination with either bonemeal or phosphate in doses of 0 lb., 10 lb., 20 lb., P_2O_5 in each case, have shown that there was a progressive increase in grain yield as the dosage of green leaf was increased, 5,000 lb. giving the best yield. In phosphatic manure, no marked differences were seen and 20 lb. P_2O_5 gave the best yields.

Samalkota.—Application of 2 cwt. of superphosphate, in combination with green manure at 4,000 lb., improved the yield by nearly 23 per cent over green manures alone.

Buchireddipalem.—Increased yields were obtained with phosphatic manures in conjunction with green leaf or groundnut cake, than with phosphatic manures alone.

Palur.—Supplementing green leaf with artificials, such as bonemeal with potash or lime and different types of phosphatic manures, such as bonemeal, fish guano and Kossier phosphate, did not result in any appreciable increase of yields.

Pattukkottai (1941–44).—Green leaf and superphosphate in different doses were tried to get at the optimum dose. In one year, 8,000 lb. of green leaf with 100 lb. of superphosphate gave the maximum yield, while in another year 8,000 lb. of green leaf alone gave the maximum yield followed by 8,000 lb. of green leaf plus 50 lb. of superphosphate. In the third year the results were not significant.

Aduthurai (1935–41).—The effect of different doses of green leaf alone and in combination with varying quantities of bonemeal were studied. The results indicate that 4,000 lb. to 6,000 lb. of green leaf in combination with 50 lb. of bonemeal was the most beneficial for rice.

Organic manures v. *fertilizers—Pattambi.*—The effect of nitrogen in the form of organic manures and fertilizers was compared. The following treatments were tried: (1) No manure, (2) cattle manure at 5,000 lb., (3) green leaf at 5,000 lb., (4) niciphos at 75 lb. per acre, (5) niciphos 75 lb. plus ammonium sulphate to make up 'N' to 30 lb. per acre.

Green leaf and ammonium sulphate were found to be superior to other manures. The yield in the case of green leaf was higher than that of ammonium sulphate but the difference was not significant.

Optimum dose of manures—Pattukkottai (1945–50).—To determine the economic doses of ammonium sulphate, superphosphate or ammonium phosphate, over a basal dose of green leaf plus groundnut cake, an experiment was conducted using different combinations of manures. The results were rather varying, but indicate that 5,000 lb. of green leaf plus 250 lb. of groundnut cake plus 100 lb. of ammonium sulphate plus bonemeal to supply 25 lb. of P_2O_5 was the best combination.

Trials with synthetic farm-yard manure—Aduthurai (1927–31).—Synthetic farm-yard manure was prepared out of waste products like rice stubbles, hedge clippings, etc., and was tested against loose-box manure and village cattle manure. The results proved that synthetic farm-yard manure was the best among the three manures used. Another experiment with compost, cattle manure and ammonium sulphate in different combinations was conducted from 1939–41. Ammonium sulphate applied alone gave the best results.

Pattambi.—Compost manure, cattle manure and green leaf in varying doses were compared. Green leaf at 8,000 lb. gave the highest yield and was on a par with cattle manure at 20 tons. Cattle manure at 10 tons, 4,000 lb. of green leaf and 20 tons compost were on a par.

Sheep manuring—Samalkota.—Sheep manuring, equivalent to the cost of raising a green manure crop, was found to be as useful as the latter in respect of grain yield.

Night soil—Samalkota.—Night soil was found to be as efficacious as farm-yard manure and green manure.

Molasses experiments—Central Farm, Coimbatore (1933–38). —Molasses at doses varying from 4 to 7½ tons per acre was compared with no manure. The results were not significant and there was no residual effect either.

Aduthurai.—Molasses was tried as a manure for rice and compared with no manure. During the first year the results were not significant. But in the succeeding years plots manured with molasses gave significantly better yields than no manure plots.

Groundnut husk as manure—Paddy Breeding Station, Coimbatore.—Groundnut husk was applied in different doses. The manured plots gave 8 to 9 per cent higher yields over the control but the differences were not statistically significant.

Fish guano—Pattambi.—Fish guano was tried as a manure for paddy at 200 lb. and 400 lb. doses. The results indicated that fish guano was good for rice, but a dose of 400 lb. was necessary to equal the effect of 4,000 lb. of green leaf.

Samalkota.—Fish guano was found to be slightly less efficient than green leaf.

Gingelly cake as manure—Paddy Breeding Station, Coimbatore (1943–45).—Gingelly cake was compared with groundnut cake and no manure. The results showed that on the basis of nitrogen gingelly cake is quite as efficacious as groundnut cake. But due to the high cost of the unit value of nitrogen in gingelly cake it is uneconomical to use it as manure.

Complex experiment with different oil cakes at four levels.—Groundnut cake, castor cake and neem cake at 0 lb., 20 lb., 40 lb. and 60 lb. 'N' per acre were compared. The results obtained from the trials at different stations are as follows :—

Paddy Breeding Station, Coimbatore (1942–47).—Neem cake was better than the other cakes of groundnut and castor during years of drought or inadequate water-supply. In general, there was a progressive significant increase in yield with an increase in the level of nitrogen.

Pattambi.—Neem cake gave better results than groundnut cake or castor cake. There was a progressive increase in yield from 20 to 60 lb. of nitrogen supplied per acre.

Aduthurai (1943–45).—There was no difference between the three types of oil cakes for the same dosage of nitrogen but in all cases the higher the dose of nitrogen the greater was the yield.

Pattukkottai (1943–45).—For Kuruvai crops castor cake was found to be the best in one year, while neem cake was best in the next year. With regard to levels of 'N', higher doses of 'N' gave significantly higher yields.

Anakapalle.—Trials with groundnut cake, castor cake and pungam cake at 0 lb., 20 lb., 40 lb. and 60 lb. of 'N' per acre showed that all cakes were equally good and increased doses of cake yielded correspondingly increased yields in paddy.

Complex experiment with cake, wood-ash and super-phosphate—Pattambi.—Experiments to find out the influence of different proportions of 'N', K_2O and P_2O_5 have shown that under Pattambi conditions there is very little response to P_2O_5. A combination of leaf, cake and ash gave the maximum yield.

CALCINED BONE *v.* BONEMEAL *v.* SUPERPHOSPATE.

Paddy Breeding Station, Coimbatore (1943–47).—The comparative effect of bonemeal, bone-char (calcined bone) and superphosphate with a basal dressing of green manure was compared with no manure as control. The results showed that phosphatic manures in conjunction with green leaf were better than phosphates alone. The calcined bone did not show any superiority over the other two phosphatic manures.

Ambasamudram.—Calcined bone, superphosphate and bonemeal, to supply 25 and 50 lb. P_2O_5 per acre were applied over a basal dressing of 5,000 lb. of green leaf per acre. There was no marked difference in yield between the different forms of phosphatic manures used in this experiment.

Buchireddipalem.—Calcined bonemeal was found to be the best of the three manures tried, namely (calcined bone, bonemeal and super) when applied for an equal basis of 30 lb. of P_2O_5 per acre.

Calcined bone v. *Raw bone-meal—Aduthurai* (1943–46).—There was no significant difference between calcined bone and raw bone-meal.

Pattukkottai (1944–47).—Raw bonemeal and calcined bone-meal were applied in combination with green leaf and groundnut cake. Calcined bone-meal was found to be as good as raw bone-meal.

Palur (1946–48).—Raw bone-meal and calcined bone-meal were compared with no manure over a basal application of 6,000 lb. of green manure. The results indicated that there was no difference between the calcined bone or bone-meal.

Bone-meal v. bone-jelly—Aduthurai (1933–36).—There was no significant difference between bone-meal and bone-jelly as manures for rice when tried in combination with green leaf and ammonium sulphate.

Steamed bone-meal v. *raw bone-meal—Aduthurai* (1941–44).—There was no difference between steamed bone-meal and raw bone-meal.

Bone-meal, super-phosphate and ammonium phosphate—Pattambi.—The three phosphatic manures: bone-meal, super-phosphate and ammonium phosphate, to supply 30 lb. P_2O_5 were compared on a basal dressing of 4,000 lb. of green leaf per acre. Significant increases over no manure were obtained by the application of either green manure or green manure plus P_2O_5. Differences between the various forms of phosphatic manures applied were not significant.

Kossier phosphate—Paddy Breeding Station, Coimbatore (1931–1933).—An experiment to test the efficiency of Kossier phosphate, a finely ground mineral phosphate containing 30 to 32 per cent P_2O_5 and 4 per cent 'N' was conducted for two years. The results did not show anything in favour of Kossier phosphate as compared to other phosphatic manures. The same experiment was conducted at Aduthurai and Pattambi also and the results were similar.

Tetra-phosphate and Trichy-phosphate experiment—Central Farm, Coimbatore (1942–43).—The results have shown that tetra-phosphate in combination with green manure was superior to Trichy-phosphate.

Ammonium phosphate—Central Farm, Coimbatore (1924–26).—Ammonium phosphate to supply 50 lb. 'N' was applied and compared with no manure. The treated plots gave significantly higher yields over no manure plots.

Basic silicophosphate—Pattambi.—This phosphate, which was said to be good for lime deficient soils, was compared with and without a basal dose of green manure with no manure as control. The results did not show any advantage in applying basic silico-phosphate.

Hyperphosphate experiments.—Two samples of a fine ground, commercial phosphate, under the name of Hyperphosphate, which

analysed 26/27 and 28/29 per cent of P_2O_5 were compared at several research stations against bone-meal and superphosphate in 1949–50. Two levels, namely, 30 and 45 lb. of P_2O_5 per acre were tried in all these forms of phosphatic manures over a basal dressing of 5,000 lb. of green leaf per acre. The results showed that in no case was hyperphosphate superior to other forms of phosphatic manures at any of the stations it was tried, e.g., at Coimbatore, Pattambi, Ambasamudram, Aduthurai or Maruteru. A similar experiment was conducted on ryots' fields, when the plots that received bone-meal were found to give higher yields than those which received hyperphosphate.

Manuring the preceding green manure crop with phosphates.—Experiments on the direct application of phosphatic manures to rice have shown rather variable results. While on loamy soils and the less clayey types, these phosphates had a more pronounced effect than in heavy clays, in general, the increased yields secured from phosphate applications were not commensurate with the cost.

Experiments in other countries have shown that the nitrogen content in the soil was higher when the green manure legumes were fertilized with phosphates. Experiments have been started at the several research stations to test this aspect and the results are awaited.

Effect of applying ammonium sulphate at different levels of 'N'—Paddy Breeding Station, Coimbatore (1938–41).—Ammonium sulphate at different levels of 'N' were applied at different stages of crop growth over a basal dressing of green leaf and compared with no manure. From the results it was noted that there was a progressive increase in the yield of grain corresponding to the increase in dosage of 'N' applied, but when the rainfall is above the average, this effect of ammonium sulphate was not in evidence.

Ammonium sulphate v. *ammonium nitrate—Mangalore* (1948–1949).—Ammonium nitrate and ammonium sulphate were compared and were found to be equally efficacious.

Pattambi.—There was no difference between ammonium sulphate and ammonium nitrate for the same level of 'N' for rice.

Sodium nitrate and ammonium sulphate experiments—Paddy Breeding Station, Coimbatore (1935–37).—Previous field experiments at Paddy Breeding Station (1926–30) had shown that sodium nitrate was not such a suitable fertilizer for rice as ammonium sulphate. Since it had been shown that nitrogen was taken up by the rice plant in the form of ammonia in the early stages and as nitrate in the later stages, and that a mixture of ammonium sulphate and sodium nitrate gave better results than either of them alone, this experiment was carried out with ammonium sulphate and sodium nitrate singly and as a mixture in different

proportions and compared with no manure. The results showed conclusively that ammonium sulphate was the best manure for rice.

Pattambi.—Ammonium sulphate and sodium nitrate were tried alone and in different combinations and compared with no manure. Sulphate of ammonia when applied alone gave the best results.

Sodium nitrate experiment—Central Farm, Coimbatore (1925–1933).—Sodium nitrate in combination with farm-yard manure in different proportions was tried. Results indicated that sodium nitrate in combination with farm-yard manure in the proportion of 3 : 2 to supply in all, 50 lb. of nitrogen gave the best results.

Aduthurai (1926–30).—Chilian nitrate of soda was tried in combination with cattle manure. Though the yields of grain and straw were higher in manured plots, the cost of the manure was higher than the profit from the increased yields.

Cyanamide experiment—Central Farm, Coimbatore (1927–31).—Cyanamide alone and in combination with superphosphate was tried over a basal dressing of 2,000 lb. of green manure per acre. Super at 1½ cwt. in combination with cyanamide at 2 cwt. per acre gave the best yields.

Ammonium sulphate and super-phosphate—Aduthurai (1935–1941).—Ammonium sulphate and super-phosphate were tried alone and in different combinations without any basal dose of green leaf or organic manure. There was a greater response to nitrogen and 20 lb. of P_2O_5 per acre was found to be the best.

Ammonium sulphate and Niciphos—Pattambi.—Niciphos alone and in combination with ammonium sulphate, green leaf and cattle manure were compared with no manure. Green leaf manuring at 5,000 lb. per acre showed an increase of 10 per cent over no manure. Green leaf and ammonium sulphate were more or less equal and superior to other organic manures.

Ammonium sulphate and groundnut cake—Buchireddipalem.—Ammonium sulphate and groundnut cake gave increased yields than other nitrogenous organic manures like farm-yard manure, compost and "Pattimannu" on an equal basis of 40 lb. 'N' per acre.

Pattukkottai (1945–48).—The experiment was to determine whether ammonium sulphate can fully or partly replace groundnut cake when applied with green leaf and bone-meal. The results were varying but the indications were that 5,000 lb. of green leaf plus 100 lb. of bone-meal plus 100 lb. of ammonium sulphate applied four weeks after planting would give the best yields.

Lime experiment—Mangalore.—Lime at 1,000, 2,000, 3,000 lb. per acre with and without green leaf at 4,000 lb. per acre were tried. The indications were that the application of lime was beneficial to rice under Mangalore conditions.

Pattambi.—The effect of lime applied at the rate of 500, 1,000, 2,000, 3,000 lb. per acre with and without a basal dressing of green leaf at 4,000 lb. per acre was studied. It was found that higher doses of lime gave higher yields and that 3,000 lb. of lime per acre in combination with green leaf gave 10 to 15 per cent increased yields over controls.

Ambasamudram.—Trials of lime application up to 1,500 lb. per acre showed that 1,500 lb. application with leaf is beneficial to paddy.

Balanced manurial experiment—Ambasamudram (1944–48).—The experiment was started with the object of improving grain setting in rice, by the application of nitrogen, phosphates and potash in varying doses. The manures were applied alone and in combinations over a basal dressing of 48 lb. ' N ' per acre, in the shape of groundnut cake applied just before planting. It was found that from the point of yield no marked increase was noticeable in plots receiving phosphates or potash. The plot receiving groundnut cake alone continued to give the best yield. The general conclusion was that ' N ' alone was the determining factor with regard to yield and there was no real need to apply potash or phosphates to rice under Ambasamudram conditions.

Maximum potentiality experiment.—Experiments were conducted in 1947–49 in a number of research stations, viz., at Coimbatore, Pattambi, Aduthurai, Buchireddipalem and Maruteru to assess the effects of maximum doses of nitrogen, phosphoric acid and potash applied singly and in combination on rice yields. The treatments included five levels of nitrogen at 0 lb., 30 lb., 60 lb., 90 lb. and 120 lb. per acre, three levels of phosphoric acid 0 lb., 30 lb. and 60 lb. and two levels of potash 0 lb. and 60 lb. per acre. The results indicated that a proportionate response existed only in the case of nitrogen doses but not to potash or phosphoric acid at any level whether singly or in combination.

Palur (1947–48).—Nitrogen at 30 lb., 112 lb., 225 lb. and 500 lb., phosphoric acid at 10 lb., 22·5 lb., 45 lb. and 100 lb. and potash at 20 lb., 41 lb., 82 lb. and 100 lb. was tried on four varieties of rice. It was observed that in all the four varieties the crop lodged badly with higher dosage and grain setting was affected. The lowest dose of manure gave the highest yield of grain and there was a gradual decrease in yield with increase in the dose of the manure.

Time of application of manure—Ammonium sulphate—Paddy Breeding Station, Coimbatore.—Ammonium sulphate at different doses was applied at different times to paddy crop. The best results were obtained when the manure was applied 45 days after planting.

Pattambi.—Ammonium sulphate was applied one, two, three, four, five and six weeks before flowering over a basal dressing of green leaf. The trials have shown that the application four weeks before flowering gave the highest yield followed by five and six weeks before flowering.

Aduthurai (1931–34).—Ammonium sulphate was applied at different stages of the growth of the crop and also just prior to planting in combination with phosphatic manures. It was established that to derive the maximum effect of the sulphate its application at 30 lb. nitrogen per acre two months after planting was the best in the case of samba crop.

Ammonium sulphate and oil-cake—Paddy Breeding Station, Coimbatore (1937–41).—Ammonium sulphate and oil cake (castor and groundnut) at 30 lb. ' N ' were applied at different intervals of growth, i.e., at planting, 30 days after planting, 45 days, 30 days and 15 days before flowering. Of the manures tried at the same nitrogen level, ammonium sulphate tops the list followed by groundnut cake and castor cake. The results for time of application were not significant.

Groundnut cake—Pattambi.—Groundnut cake was applied at different stages of growth. The results indicated that the cake can be applied even after the crop establishes and not at the time of planting alone.

Buchireddipalem.—No significant result was noticed in applying groundnut cake from the time of planting up to shot-blade stage (90 days after planting) in the Molakolukulu, the long-duration variety. It is best to apply groundnut cake half at the time of planting and the remaining half after the first weeding, rather than applying all the dose either at planting or after first weeding.

Super-phosphate—Paddy Breeding Station, Coimbatore (1937–1940).—Super-phosphate on a basal dressing of green leaf manure and no manure applied at different times of the growth period of the crop was compared. It was noted that the application of super-phosphate at 30 lb. P_2O_5 per acre at the time of planting or 10 to 20 days before planting over a basal dressing of 4,000 lb. of green leaf per acre is advantageous.

Pattambi.—Application of super-phosphate before final ploughing and levelling did not show any significant difference.

Trial of spraying minor elements—Copper sulphate—Paddy Breeding Station, Mangalore.—The effect of spraying a young crop of rice with copper sulphate solution at 15 lb., 30 lb., 45 lb. of the chemical per acre was studied. Heavy showers were received a week after spraying and the results were not significant. However, there were indications that spraying with copper sulphate was beneficial.

Pattambi.—An experiment to test the efficacy of copper sulphate in small doses to rice crop was tried by using graded doses from 5 to 100 lb. per acre. The treatment had no apparent effect on yield.

Inorganic catalysts.—Inorganic catalysts like ferrous sulphate and potassium permanganate in small doses are believed to have some beneficial catalytic effect upon organic matter. These were tried alone and in different proportions with and without a

basal dressing of green manure at Maruteru, Pattambi and at Coimbatore. It was found that there was no action of the catalysts in increasing the yield either alone or in combination.

Manuring.—It may be well to summarize at this stage the main findings of the manurial experiments carried out so far in the different research stations. It is found that manuring the seed-bed alone, even in heavy doses, is not enough to ensure a good yield, but an adequate manuring of the planted field also is necessary. Green manures in any form, whether grown as a crop and ploughed in or transported as leafy shoots and trampled in, are always useful and give progressively higher yields up to 8,000 lb. of green leaf per acre, though the optimum seems to be round about 4,000 lb. to 5,000 lb. No difference was seen between different kinds of green manure crops like daincha, sunnhemp or wild indigo or between different species of green leaf; the increase in rice yield depending mainly upon the quantity of nitrogen that is supplied in this form.

Oil-cakes too are equally useful as suppliers of nitrogen and no real difference was seen in the effect of different cakes, so that the choice of any particular kind depends mainly on its cost and availability. With regard to bulky organic manures like cattle manure, compost, synthetic farmyard manure, sheep manure, fish guano and nightsoil, all are more or less equal in effect and similar to green manures in action. Their optimum doses are conditioned by the fact that 30 lb. to 40 lb. of nitrogen per acre is the optimum for rice, irrespective of the form in which this nitrogen is supplied. Ammonium sulphate has been found by test to be the best among all the artificial fertilizers for rice. The best time to apply this fertilizer is 30 days to 60 days after transplanting depending on the duration of the variety. It is recommended that at least 2,000 lb. of leaf may be used in conjunction with ammonium sulphate for rice as a general rule. The utility of molasses as a manure for rice is still not fully established and needs further study.

With regard to phosphatic manures, no marked effect was noticeable in many cases where they were tried, but on the whole the trend of the results is that it is advantageous to use a mixture of 4,000 or 5,000 lb. of green manure and some phosphatic manure to supply 25–30 lb. of P_2O_5 per acre. The particular form in which the phosphorus is supplied is of secondary importance as no great difference was found between the different manures tried. Phosphates are best applied at planting time. With regard to potash manures there seems to be no real need for them in Madras, although in a few cases wood ash in conjunction with green manures was found beneficial. Lime is useful in certain tracts like the West Coast, the optimum quantity being 3,000 lb. per acre. The merits or otherwise of applying phosphatic manures to the previous green manure crop as against their direct application to the rice crop is under investigation and no conclusions are possible at present.

Harvesting and yields.—The one common feature in the whole of South India in harvesting rice is that it is always done with sickles by women; otherwise, a great deal of local variations exist in harvest practices. In the Northern Circars, the harvest is taken up rather early when the straw is still green and the grain only just ripened. After harvest, the cut sheaves are left to dry for three or four days in the field before they are put into stacks. It is believed that the grain undergoes some kind of curing process in these stacks. They are sometimes left unthreshed for as long as four months after harvest.

As a contrast, rice harvest in the south in the Tanjore district is delayed until even the straw is dead ripe, while other operations like threshing, winnowing, etc., are all finished on the same day as harvest. Where the fields could be allowed to get dry before harvest, the straw is cut close to the ground, but where this is not possible, as in Malabar, only the earheads are cut and gathered and the straw is cut later or else left to be grazed by cattle. In the Circars deltaic areas, the second crop is usually harvested leaving a longer stubble than in the first crop. This stubble is subsequently ploughed in and serves as manure.

The yield of paddy (rice in husk) per acre naturally varies a great deal depending on the varieties, soil conditions, season in which they are grown and numerous other factors. The official estimate of the normal yield from an irrigated rice crop in the Madras State is 1,794 lb. per acre while that of unirrigated rice 1,303 lb. per acre. Under favourable conditions of water-supply and other factors, yields of 4,000 lb. to 5,000 lb. per acre have been recorded in certain districts. Short-duration varieties generally yield less than long-duration varieties, and yields from varieties grown in single-crop lands are higher than the same variety grown on double-crop lands. The incidence of diseases pull down yields by as much as 50 per cent when severe, while in bad cases the entire crop may be lost. If the rainfall is deficient during the growing period of the crop, then too, the yield is adversely affected.

The following are average figures from crop-cutting experiments made under the auspices of the Indian Council of Agricultural Research :—

District.	Number of experiments.	Average yield of dried paddy in pounds per acre.	Standard error.
1 Visakhapatnam	216	1,243	4·3
2 East Godavari	96	1,456	8·5
3 West Godavari	105	1,898	4·7
4 Krishna	108	1,706	5·3
5 Guntur	96	1,668	7·6
6 Nellore	136	1,440	5·9
7 Chingleput	72	1,185	8·1
8 North Arcot	99	1,539	4·2
9 Chittoor	81	1,785	5·5
10 South Arcot	70	1,427	9·3
11 Tiruchirappalli	42	1,901	5·5
12 Tanjore	66	1,399	5·4
13 Malabar	106	1,244	4·4
14 South Kanara	90	1,422	2·0

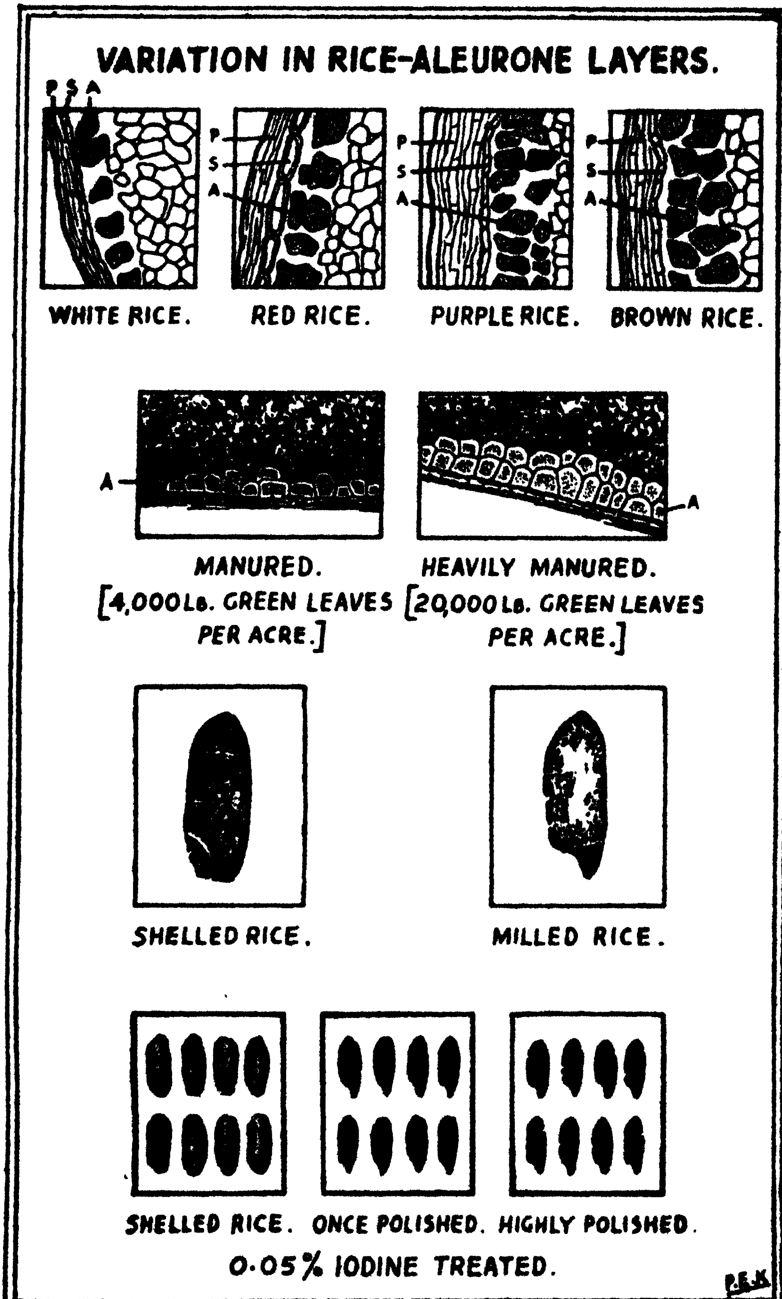
Threshing, storing, etc.—The threshing of rice is done in two stages; the grain being first beaten out of the sheaves on the ground or on suitable wooden platforms and what is left is subsequently trodden out by cattle. In the Northern Circars, the sheaves are taken out of the stacks and spread out to be cattle-threshed in one stage itself. After threshing the produce is cleaned of all chaff, mud particles and other foreign material. No winnowing machine has so far come into vogue in the State and winnowing is done only by throwing up the threshed produce against the wind and allowing the chaff and half-filled grains to be blown off to some distance. The sound grains fall in a heap nearer and are collected and stored.

Before the produce is stored it has to be well dried first, the amount of drying needed depending upon the method of harvest, whether done early or late, and how it is going to be stored, whether as seed or as a foodgrain for consumption. For storage as seed, the drying has to be more thorough than when it is intended for food. The dryage varies from 9 to 15 per cent of the harvested weight.

Storing.—The methods adopted for storing rice (or paddy) varies widely in different tracts of the State. In the Circars, rice is stored in specially built granaries called "*Gathis*". These are built on pillars with walls of bamboo mats thickly plastered over and with a well built roof on top with wide projecting eaves. These can accommodate 300 to 1,000 bags of paddy grain weighing 160 pounds each. Another method is in circular straw twists built up on masonry platforms or elevated ground. These "*puris*" are able to hold up to 200 bags of grain and are common in Tanjore as well as in the northern districts. A third method of storing is in shallow underground pits, when it is intended to store the grain for a short period. This practice is found in Nellore, Srikakulam and Visakhapatnam districts and is believed to aid in curing the grain and improve its cooking quality. In Tamil districts paddy is commonly stored in mud bins, while granaries made of wooden planks are common in Malabar. In South Kanara straw bundles or bales called "*muras*" are used for storing paddy. Paddy grain intended for seed purposes as well as husked rice are stored in gunny bags.

Storage experiments conducted at Paddy Breeding Station, Coimbatore, have shown that the weight of stored paddy decreases during storage if the grain was not well dried before storing. On the other hand grain that has been thoroughly dried before storing increases in weight during storage indicating that grain if dried beyond a certain stage re-absorbs moisture from the atmosphere and gains in weight. Thorough drying is of course necessary for seed paddy, but when such grain is milled for food purposes it is liable to have a high proportion of broken rice.

Milling.—For consuming as a food grain rice has to be freed from its husk. This is done by hand pounding or by milling. The former is the time honoured method whereby paddy is pounded



P = PERICARP. (OUTER LAYER) S = SPERMODERM. (SEED COAT) A = ALEURONE. (NUTRITIOUS LAYER)

Plate 13.

with a pestle and mortar. Milling is now the most extensively adopted method of handling large quantities of paddy. In these mills the grain is passed through shellers for de-husking and then through hullers for polishing. The proportion of husked rice to paddy varies with varieties and also the nature of the milling and the degree of polish given to the rice. The official figure as given in the Season and Crop Report of Madras State is 67 per cent. as the average outturn of rice to paddy. (Plate 13.)

The results of milling tests on the outturn of rice to paddy conducted in different parts of the State are given below :—

Colouring of rice.—In the preparation of rice for the market, millers often add some colouring matter during polishing depending upon the requirements of the tract for which the rice is intended. The usual colouring matter used is turmeric or yellow " Ochre " for the yellow tinge and red " Ochre " for the red tinge.

Parboiled rice.—In most parts of the southern districts of the State parboiled rice is extensively used for consumption. Parboiled rice is prepared by steeping the grain in water for one to three days according to the variety and then the soaked grain is steamed under pressure for 10 to 20 minutes. The steamed grain is quickly removed and spread in thin layers for drying on special floors. Milling of the parboiled rice is done in the same way as for raw rice.

By-products of milling.—Husk, bran, and broken rice are the by-products of milling. The husk is used as fuel. The bran consists of highly nutritive substances removed from the grain during hulling and is very valuable as cattle feed. The broken rice is largely consumed as such by the poorer classes and labourers.

Results of experiments of the Outturn of rice to paddy (mills) with different polishing.

Experiment number.	*Variety of paddy.*	*Age of paddy.*	*Pre-treatment of paddy, raw or par boiled.*	*Place of production.*	*Degree of polish.*	*Quantity of paddy taken for the experiment.* (POUNDS).	*Percentage outturn of rice to paddy (rice includes broken rice).*
I	Kusuma	New	Raw	Vijayavada (Krishna district).	Shelled	16,622	75·2
					Once polished		72·6
					Twice polished		69·8
					Thrice polished		68·0
II	Red Kar	..	Parboiled	Coimbatore	Shelled	3,556	75·7
					Once polished		72·6
					Twice polished		71·8
III	Nellore Samba	New	Do.	Tanjore	Once polished	12,872	69·3
					Twice polished		68·0
					Thrice polished		67·6
IV	Kattai Samba (Korangu samba).	Do.	Raw	Mannargudi (Tanjore district).	Shelled	3,034	74·8
					Once polished		67·2
					Twice polished		66·4
					Thrice polished		65·8
V	Do.	Old	Do.	Do.	Shelled	2,994	76·0
					Once polished		68·3
					Twice polished		66·6
					Thrice polished		66·3
VI	Do.	New	Parboiled	Do.	Once polished	2,975	70·5
					Twice polished		69·7
					Thrice polished		69·1
VII	Do.	Do.	Do.	Do.	Once polished	2,984	68·7
					Twice polished		67·7
					Thrice polished		67·0

Pests and diseases.—The potential outturn from the ten million acres under rice in the State of Madras is reduced on account of losses caused by numerous pests and diseases. More than thirty different species of insects are known to attack rice, though fortunately only a few of them are really serious and capable of causing severe loss. Field rats and crabs also cause appreciable damage and in addition there are one or two diseases that sometimes assume epidemic form and entail heavy losses. As a detailed account of rice pests and diseases is given in chapters 22 and 23, only a bare list is given below in the descending order of importance :—

Insect pests of rice—

(1) The Swarming Caterpillar (*Spodoptera mauritia* B.).
(2) The Paddy Stemborer (*Schoenobtus incertellus* W.).
(3) The Paddy Grasshopper (*Hieroglyphus banian* F.).
(4) The Rice bug (*Leptocorisa acuta* T.).
(5) The Paddy Gall-fly (*Pachydiplosis oryzae* W.).
(6) The Paddy Mealy bug (*Ripersia oryzae* G.).
(7) The Rice Hispa (*Hispa armigera*).

Pests of stored paddy and rice—

(8) The Rice Weevil (*Sitophilus* or *Calandra oryzae* L.).
(9) The Paddy Borer Beetle (*Rhizopertha dominica* F.).
(10) The Flour Beetle (*Tribolium castaneum* M.).
(11) The Rice Moth (*Corcyra cephalonica* H.).

Non-insect pests of rice.—In addition to the insect pests listed above, two or three species of rats like the mole rat (*Gunomys Kok* G.), the Gerbil (*Tatera cuveri* W.) and the house rat (*Rattus rattus rufescens* Gran.) cause considerable damage and loss in the field as well as in the godown. A detailed account of these pests will be found in Chapter 22 along with the appropriate methods for their control. The Chapter 23 deals with the diseases of crop plants that are commonly encountered in Madras and includes an account of the diseases that affect the rice crop as well.

Food value of rice.—The average composition of 43 varieties of rice is compared with other important cereals :—

Grain.	Starch.	Protein.	Fat.	Ash.
	PER CENT.	PER CENT.	PER CENT.	PER CENT.
Rice	88·87	8·5	1·12	1·11
Wheat	80·37	11·2	2·03	3·44
Sorghum ..	80·98	10·88	4·13	2·29
Ragi	67·76	10·64	5·56	3·63

The above figures would show that rice is rich in starch but poorer in fat and minerals than other foodgrains.

The data given above shows differences from those found in the Health Bulletin No. 23 issued by the Manager of Publications, Civil Lines, Delhi, 1941, for the Government of India. The reason is that the Health Bulletin figures are based on analytical data relating to single samples obtained from the Coonoor Bazaar, while the figures reported in the memoirs are the averages of a larger number of samples.

The figures are on moisture free basis and do not include the content of crude fibre.

Quality in rice.—Quality is an attribute that is difficult to define in rice and is apt to vary with different tastes and interests engaged in the rice industry. But from the general consumers' point of view, the main criterion of quality in rice may be taken as its nutritive value. The use of different manures has been found to influence the thickness of bran which is the chief source of protein and minerals in rice and thereby improve its nutritive value. It is generally believed that rice grown under dry conditions is more nutritious than from swamp conditions, but actual analysis does not substantiate this belief, as rice from swamp conditions contains more of proteins and mineral matter. It is possible that the higher oil (fat) content in rice from dry conditions may perhaps explain the higher esteem in which dry rice is held.

	Proteins.	Fat.	Minerals.	P_2O_5
	PER CENT.	PER CENT.	PER CENT.	PER CENT.
Transplanted, swamp rice ..	10·99	2·23	1·47	0·70
Broadcast, swamp rice	9·06	2·32	1·31	0·69
Broadcast, dry rice	7·87	2·66	1·33	0·62

When the same variety or strain was grown on well-drained and ill-drained soils there were indications to show that the protein content was higher in rice from ill-drained soils, while calcium and phosphorus were more in rice from well-drained soils.

Varietal differences.—Different varieties of rice differ considerably in their chemical composition also. Coarse grains are richer in proteins and minerals, especially calcium, iron and phosphorus than the so called fine rices. It is also found that coloured rices are richer in these constituents than the white rices as shown below in the thickness of the bran layers :—

Grain.	Colour of rice.	Thickness of bran-layer in microns.
Coarse	Purple	62·8
Do.	Red	52·8
Do.	White	50·1
Medium	Red	54·5
Do.	White	42·8
Fine	Do.	40·7

Polishing.—Most of the nutritive substances of rice grain are contained in the outer bran layers immediately below the husk. During milling and especially in polishing, these layers are removed with the result that polished rice contains practically nothing but starch. The disease known as "beri-beri", common in exclusive rice eaters is now known to be caused by a lack of vitamin B group in the diet as the highly polished rice that is eaten contains little or no vitamin B.

Parboiling rice helps in retaining some of the proteins and vitamins within the grain, even after milling and polishing and hence is more nutritious than raw rice polished to the same degree. It is observed that during the process of parboiling, the inner endosperm tends to swell but as there is the resistance of the outer bran layer and the inelastic husk, this swelling results in the bran layer or at least a portion of it getting imbedded inside the endosperm. Some of the vitamin B also from the bran layer diffuses into the inner layers of the grain and endosperm.

Hand pounding.—Losses in the nutritive value of rice are minimised when the husk alone is removed, keeping the bran layer intact. Rice can be shelled like this by special wooden hand grinders, the next best method being by hand pounding with a mortar and pestle. The following data give the analysis of rice of different kinds :—

	Protein.	Fat.	Ash.	Phosphoric acid.
	PER CENT.	PER CENT.	PER CENT.	PER CENT.
Shelled rice	8·53	1·76	1·47	0·87
Hand pounded raw rice.	7·76	1·22	1·12	0·57
Milled raw rice ..	6·78	0·73	0·64	0·37
Milled parboiled rice ..	7·82	0·84	0·98	0·58

Cooking tests.—It is necessary to know before judging the cooking qualities of any variety of rice, the time taken for complete cooking, the volume of the cooked rice in relation to the rice taken, the volume and viscidity of the supernatant liquid that has to be drained off after cooking and the appearance of the cooked rice. A method of estimating the comparative cooking qualities of different strains of rice has been devised at the Paddy Breeding Station, Coimbatore, where definite weighed quantities (20 gms.) of each sample after shelling are first soaked in water for ten minutes and then cooked in a water bath, after adding four times the weight of water (80 gms.). The time taken for cooking and other points are determined on the cooked sample.

Tests with a large number of samples, shelled, milled or polished to different degrees, have shown that (1) a certain amount of uniform polishing is necessary for good cooking quality. This polishing should also be at a minimum if the nutritive value of the rice is to be retained, (2) the time taken for cooking shelled rice in general and red rices in particular is longer than the time required by the same samples when slightly polished, (3) the volume expansion of polished rice on cooking is comparatively greater and more uniform than in shelled rice where the grains split on the sides in an irregular fashion and form a pasty mass, (4) heating shelled rice in a dry oven for a few minutes before cooking reduces the time taken for cooking but does not improve the expansion ratio, nor the irregular splitting of grains, (5) the pastiness of newly harvested rice on cooking is due to a starch liquefying enzyme known as Q-amilase that is present in such rices. On storage for

some time, this enzyme gets inactivated and hence old rice cooks better, giving a greater volume for the rice taken and does not get pasty on cooking. Recent studies at Coimbatore have shown that as a result of storage there is a reduction in granule size of rice starch, a change in its granular make up and also a probable change in its molecular configuration. Improvement in cooking quality occurs slowly or rapidly with different methods of storage being fairly rapid when the grain is stored in underground pits. It can also be hastened by subjecting the rice to dry heat for a few minutes prior to cooking.

Scent and aroma.—Certain varieties of rice like *Basumathi* have a characteristic scent which is evident on smelling or chewing and gets accentuated on cooking. Such scented varieties are usually used only for special purposes like the preparation of "*Pulavu*". The scented character is heritable in simple Mendelian fashion. *Puttu* rice is another special variety that is cultivated in limited areas and quantities. It is also known as glutinous rice although it contains no gluten but only starch in a different form. This rice cannot be cooked like ordinary rice but can only be steamed. Mixed with sugar and shredded coconut, it makes a very delicious and wholesome dish.

The Rice Research Station, Berhampur (Ganjam District).

Number and name of strain. (1)	*Normal time of harvest.* (2)	*Other particulars.* (3)
BAM 1. Boroponke	Third week of November.	Isolated from *Boroponke* of Ganjam district, largely grown in rainfed areas and in high level field in canal areas where there is generally water scarcity at the ripening stage. It grows rather quickly. The heading is good but the grain is coarse. Amongst lower classes, the variety is preferred for parboiled rice. Recorded an increase of 19 per cent over ryots' bulk. Acre yield is 2,000 lb. *Grain size :* Length (L)—9·1 mm.; Breadth (B)—2·7 mm.; Thickness (T)—2·0 mm.; *Glume colour :* Straw coloured. *Rice :* Red.
BAM 2. Boroponke	Do.	Recorded an increase of 16 per cent over ryots' bulk. Tall growing and vigorous. Acre yield is 2,700 lb. *Grain size :* L—8·7 mm.; B—2·6 mm.; T—1·9 mm. *Glume colour :* Straw. *Rice :* Light red.
BAM 3. Bayyahunda	Last week of November	Isolated from *Bayyahunda*, the premier variety of the Ganjam district. The heading and setting of grain is good. Recorded an average increase of 19 per cent over ryots' bulk. It is grown extensively in Visakhapatnam district. Average yield 3,000 lb. per acre. *Grain size :* L—8·6 mm.; B—2·5 mm.; T—1·9 mm.; *Glume colour :* Straw coloured. *Rice :* White.
BAM 4. Bayyahunda	Do.	Recorded an average increase of 16 per cent over standard. Acre yield 3,000 lb. *Grain size :* L—8·5 mm; B—2·4 mm.; T—1·9 mm.; *Glume colour :* Straw coloured. *Rice :* White.
BAM 5. Ratnachudi	Beginning of December	Isolated from *Ratnachudi*, an important variety in some taluks of the Visakhapatnam district. It has a stiff straw and does not lodge as early as other varieties. An increase of 14 per cent over the ryots' variety was recorded. An acre yield of 3,000 lb. was obtained. *Grain size :* L—8·2 mm.; B—2·4 mm.; T—1·8 mm. *Glume colour :* Piebald gold. *Rice :* White.
BAM 6. Ratnachudi	Do.	Recorded 15 per cent increased yield over the local. Acre yield 3,200 lb. on the average. *Grain size :* L—8·0 mm.; B—2·4 mm.; T—1·8 mm. *Glume colour :* Piebald gold. *Rice :* White.
BAM 7. Navakotisannam.	Do.	Isolated from *Navakotisannam*, of some importance in Ganjam district and parts of Visakhapatnam district. It is suitable to localities with favourable irrigation facilities. It is a robust variety, with thick straw, few tillers and short bunched heads. Had given 19 per cent increased yield. Acre yield 2,600 lb. *Grain size :* L—8·1 mm.; B—2·4 mm.; T—1·9 mm. *Glume colour :* Straw coloured. *Rice :* White.

The Rice Research Station, Berhampur (Ganjam District)—cont.

Number and name of strain. (1)	*Normal time of harvest.* (2)	*Other particulars.* (3)
BAM 8. Navakotisannam.	Beginning of December ..	Recorded an average of 14 per cent increase over local. Purple coloured sheath and tip of grain. Yield 2,600 lb. per acre. Suited to rich and low-lying areas and withstands late planting and scarcity of water. *Grain size*: L—8·3 mm.; B—2·6 mm.; T—1·9 mm. *Glume colour*: Straw coloured. *Rice*: White.
BAM 9. Mypali	First week of December ..	Isolated from *Mypali*, a common variety in Visakhapatnam district and to some extent in Ganjam district under the name of Mohipalo. It is a robust coarse variety standing well in high winds and reported to resist water-logging. Recorded an average increase of 24 per cent over the local. Average acre yield is 2,700 lb. *Grain size*: L—9·0 mm.; B—2·8 mm.; T—2·0 mm. *Glume colour*: Straw coloured. *Rice*: White.
BAM 10. Mypali	Do. ..	Has given 17 per cent higher yield on the average. Acre yield is 2,500 lb. *Grain size*: L—8·5 mm.; B—2·7 mm.; T—2·0 mm. *Glume colour*: Straw coloured. *Rice*: White.

Sugarcane Research Station, Anakapalle (Visakhapatnam District).

Number and name of strain. (1)	*Normal time of harvest.* (2)	*Other particulars.* (3)
AKP 1. Bobbiliganti ..	3rd week of November ..	A coarse, early type isolated from *Bobbiliganti* (No. 1) suited for high level lands. Withstands drought; yields 2,200 lb. of grain per acre normally, with a maximum of 4,000 lb. *Grain size*: L—8·7 mm.; B—3·0 mm.; T—2·0 mm. *Glume colour*: Dirty in furrows. *Rice*: White.
AKP 2. Sunkisannam ..	4th week of November ..	A very fine, early variety selected from *Sunkisannam* (No. 5) suited for very fertile, high or medium level lands. Resists drought to some extent. Yield per acre 2,500 lb. *Grain size*: L—7·9 mm.; B—2·3 mm.; T—1·7 mm. *Glume colour*: Straw. *Rice*: White.
AKP 3. Gunupursannam.	2nd week of December ..	Isolated from *Gunupursannam* (No. 47), a non-lodging variety suited for rich and well drained soils. The rice is considered to be one of the best for table purposes and fetches a premium in the market. Yields 2,500 lb. per acre. *Grain size*: L—8·0 mm.; B—2·5 mm.; T—1·9 mm. *Glume colour*: Straw. *Rice*: White, flinty.
AKP 4. Mypali	Do. ..	A high yielding, non-lodging type of *Mypali* (No. 7) popular in Visakhapatnam. It is suited to medium level lands. Its normal yield is 2,800 lb. per acre. Withstands extremes of weather and adverse soil conditions. *Grain size*: L—9·0 mm.; B—3·9 mm.; T—2·0 mm. *Glume colour*: Straw. *Rice*: White.

AKP 5. Mypali	3rd week of December	A high yielding strain from *Mypali* (No. 30) suited to rich, low-lying areas where a late Mypali is preferred. Normal yield is 2,900 lb. per acre. *Grain size*: L—8·8 mm.; B—2·8 mm.; T—2·0 mm. *Glume colour*: Straw. *Rice*: Light red.
AKP 6. Mypali	2nd week of December	This is a strain selected from local *Mypali* (No. 355) yielding 12·5 per cent over AKP 4 Mypali. Though a heavy yielder, it does not stand extremes of weather and soil conditions like AKP 4 Mypali. An acre yield of 3,100 lb. has been recorded. *Grain size*: L—8·3 mm.; B—2·9 mm.; T—2·0 mm. *Glume colour*: Straw. *Rice*: White, flinty.
AKP 7. Bayyahunda	End of first week of December.	This is a coarse variety selected from *Palgara Bayahunda* (No. 1) of Visakhapatnam district. It is different from the fine variety of the same name grown in North Visakhapatnam. This is a vigorous growing variety suited to diverse types of soil with good supply of water. Average acre yield is 2,800 lb. *Grain size*: L—8·4 mm.; B—2·8 mm.; T—2·0 mm. *Glume colour*: Straw. *Rice*: White.
AKP 8. Maharaja Bhogam.	Third week of December.	A very fine good quality rice (Maharaja Bhogam No. 4) suited to rich, low-lying areas. Tends to get chaffy in seasons of poor or ill-distributed rainfall. Its average acre yield is 2,800 lb. of grain. *Grain size*: L—7·9 mm.; B—2·3 mm.; T—1·9 mm. *Glume colour*: Straw. *Rice*: White.
AKP 9. Bangarutheega	Do.	This is a strain from *Bangarutheega* (No. 9) of the Visakhapatnam and East Godavari districts but is different from the gold-glume variety of that name grown in the South Visakhapatnam and East Godavari districts. Suited for rich and well-drained soils with plentiful supply of water. Yields 2,700 lb. per acre. *Grain size*: L—8·0 mm.; B—2·6 mm.; T—1·9 mm. *Glume colour*: Straw. *Rice*: White.
AKP 10. Bangarutheega.	Do.	Comes up well in all types of soil. Yields on a par with Bangarutheega No. 9 (AKP 9). This strain is selected from Bangarutheega (No. 155), yields 2,800 lb. per acre. *Grain size*: L—8·4 mm.; B—2·4 mm.; T—1·9 mm. *Glume colour*: Straw. *Rice*: White.
AKP 11. Ramasagaram.	Middle of December	A heavy yielding type isolated from local *Ramasagaram* (No. 221) suited to rich, low-lying areas with plentiful supply of water. This strain recorded an increase of 27 per cent grain than the local bulk. Average yield 3,200 lb. per acre. Outturn of rice 60·5 per cent, by volume and 74·2 per cent by weight. *Grain size*: L—8·7 mm.; B—3·0 mm.; T—2·2 mm. *Glume colour*: Straw. *Rice*: White.
AKP 12. Ramagada		Selected from *Ramagada* in 1947. Coarse variety with long duration and specially suited to low-lying lands. Yields 12 per cent increase over local.

Agricultural Research Station, Samalkota (East Godavari District).

Number and name of strain. (1)	*Normal time of harvest.* (2)	*Other particulars.* (3)
SLO. 1 Punasa Konamani. (*Farm Punasa*) (No. 2).	Third week of November.	Released in 1925 ; Nursery—May to June. It is very well suited to the ayacuts of the upland tanks, Yeleru basin and the higher and middle portions specially of the Eastern and Central deltas of the Godavari. This strain is popularly known as '*Farm Punasa*'. Pre-eminently suited as a medium type leaving an early start for the pulses coming in the wake of the first crop paddy, it has all along been a popular strain, both for the trader and producer maintaining its quality. Average acre yield is 3,200 lb. *Grain size* : L—8·8 mm. ; B—3·1 mm. ; T—2·3 mm. *Glume colour* : Straw. *Rice* : White.
SLO 2. Punasa Konamani (*Sanna Farm*) (No. 83).	Do.	Released in 1935 ; Nursery—May to June ; This is another type of the same kind as above without growing tall. It has non-lodging habit and coupled with the quality of the fineness of rice is in great favour in the well drained soils of the Central Delta and in the *Yeleru* basin of the Pithapuram and Kakinada taluks and comes up well in well drained soils under drought conditions. Average yield per acre is 3,600 lb. *Grain size* : L—7·9 mm. ; B—2·8 mm. ; T—2·1 mm. *Glume colour* : Straw. *Rice* : White.
SLO 3. Konamani (No. 3A).	Fourth week of November.	Released in 1933 ; Nursery—May to June ; Long duration varieties like *Konamani* are in favour where (1) paddy planting is late through late water supply, (2) where water cannot be drained off from fields from the first week of November and (3) where pulses cannot be successfully grown after paddy, due to unfavourable soil conditions. This type has replaced local Konamani in Pithapuram taluk and is popular in the upland and higher deltas. It gave 14 per cent, higher yield than the local. Average yield per acre is 3,200 lb. *Grain size* : L—8·4 mm. ; B—3·0 mm. ; T—2·0 mm. *Glume colour* : Straw. *Rice* : White.
SLO 4. Konamani (No. 87).	Do.	Released in 1933 ; Nursery—May to June ; It gave 7 per cent higher yield than the ryots' bulk. It is a good tillering type with finer grain than SLO 3. (*Konamani*). It is very popular in Razole taluk and is also grown in Pithapuram and portions of Kakinada. Average yield per acre 2,600 lb. *Grain size* : L—8·2 mm. ; B—2·7 mm. ; T—1·8 mm *Glume colour* : Straw. *Rice* : White.
SLO 5. Palagummasari (No. 7).	Third week of November.	Releсed in 1925 ; Nursery—May to June ; This is a coarse variety of medium duration. It does best on the lighter classes of soils in the upland taluks and in the higher and middle deltas. The type is an improved one in regard to quality of rice. Average yield 3,200 lb. per acre. *Grain size* : L—8·4 mm. ; B—2·8 mm. ; T—2·0 mm. *Glume colour* : Straw. *Rice* : White.

SLO 6. Punasa Akkulu. (No. 3).	Third week of November.	Released in 1925; Nursery—May to June; This is the most largely cultivated variety in the deltas of East Godavari. It thrives on poor and somewhat saline low lands; withstands submersion to some extent and is grown widely in the lower deltas. It may also be grown successfully on lands from which the surface soil had been removed, in the course of lowering the field level for free irrigation. Average yield per acre is 3,100 lb. *Grain size*: L—8·4 mm.; B—2·8 mm.; T—2·0 mm. *Glume colour*: Dirty in furrows. *Rice*: White.
SLO 7. Bontha Basangi. (No. 33).	Do.	Released in 1928; Nursery—May to June; With early planting on fertile land, it always gives high yield without lodging. Long duration varieties with a tendency to grow tall are largely replaced by this type. Yield per acre 3,000 lb. *Grain size*: L—8·2 mm.; B—3·1 mm.; T—2·2 mm. *Glume colour*: Straw. *Rice*: White.
SLO 8. Sanna Basangi. (No. 61).	Do.	Released in 1933; Nursery—May to June; Slightly later in duration than the previous one but with very fine rice, almost equal to that of GEB 24 and suited for late planting and soils of medium fertility. This strain has spread in parts of Central delta. Acre yield 2,800 lb. *Grain size*: L—8·3 mm.; B—2·5 mm.; T—1·9 mm. *Glume colour*: Straw. *Rice*: White.
SLO 9. Gorthi Rasangi. (No. 26).	Do.	Released in 1928; Nursery—May to June; It is a coarse, vigorous growing type and the most popular of the early varieties. It is spreading in habit and throws out large ears. It gave 16 per cent higher yields and has spread in the upland taluks of East Godavari where drill sowing of paddy is in practice. *Grain size*: L—8·3 mm.; B—2·5 mm.; T—1·8 mm. *Glume colour*: Straw. *Rice*: White.
SLO 10. Ratnachudi (No. 9).	Fourth week of November, or beginning of December.	Released in 1928; Nursery: May to June. It is popular in upland areas and also in the high deltas. Fine quality rice. Due to non-shedding quality of grain, this type can stand delays in harvest in adverse weather. Average yield per acre is 2,800 lb. *Grain size*: L—8·3 mm; B—2·5 mm; T—1·8 mm. *Glume colour*: Pie-bald gold. *Rice*: White.
SLO 11. Bikirisannam (No. 15-A).	Do.	Released in 1929; Nursery: May to June. A long duration, finer type with good tillering habit and fairly strong and thick culmps. It withstands lodging and is suited for areas where water does not recede from fields at harvest time and yields well on rich soils. Average yield per acre is 3,300 lb. *Grain size*: L—7·8 mm; B—2·4 mm; T—1·7 mm. *Glume colour*: Dirty. *Rice*: White.
SLO 12. Thellagarikasannavari (No. 6).	I Crop—October fourth week II Crop—April fourth week.	Released in 1926; Nursery: May to June; II crop January. A type extensively grown in the second crop (*Dalwa*) and to a certain extent in the first crop (*Sarva*) season. The type is also suited for raising from September onwards in the upland ayacuts receiving late water-supply and in delta areas that need replanting when the first crop seedlings get damaged by floods. An average yield of 2,200 lb. per acre has been obtained. *Grain size*: L—8·3 mm; B—2·9 mm; T—2·1 mm. *Glume colour*: Straw. *Rice*; White.

Agricultural Research Station, Samalkota (East Godavari District)—cont.

Number and name of strain. (1)	*Normal time of harvest.* (2)	*Other particulars.* (3)
SLO 13. Punasa Akkulu (Gova Akkulu No. 117/3).	Fourth week of November.	Released in 1941; Nursery: May to June. This is of the same duration as SLO 6 (*Punasa Akkulu*). It has yielded 18 per cent over SLO 6. (*Punasa Akkulu*). The rice is translucent and is more attractive in appearance than SLO 6. (*Punasa Akkulu*). Average yield per acre is 4,100 lb. *Grain size*: L—8·4 mm; B—2·8 mm; T—1·9 mm. *Glume colour*: Dirty in furrows. *Rice*: Pearly white.
SLO 14. Punasa Akkulu No. 101/3 (Sanna akkulu).	Do.	Released in 1941; Nursery: May to June. This strain gave an average increased yield of 18 per cent over SLO 6 (*Punasa akkullu*) with finer rice. Cultivated in East Godavari. Average acre yield is 3,900 lb. *Grain size*: L—8·1 mm; B—3·0 mm; T—2·2 mm. *Glume colour*: Dirty in furrows. *Rice*: White.
SLO 15. Konamani (No. 238) (*Podha Konamani*).	First week of December ..	Released in 1941; Nursery: May to June. This strain matures at the same time as GEB 24. The colour of the rice is translucent and is thus more attractive than the abdominal white of SLO 4 -*Konamani*). An average yield of 4,100 lb. per acre is recorded. *Grain size*: L—7·8 mm; B—2·6 mm; T—2·0 mm. *Glume colour*: Straw. *Rice*: White.
SLO 16. Kasipichodi (No. 354).	First crop—Last week of September. April for second crop.	Released in 1941; Nursery: First crop May to June; Second crop January. The crop is of recent introduction and popular in the uplands and the deltas of Godavari district. Its rice is finer than GEB 24. In wet lands, the stubbles of the crop harvested in September on ratooning yields a second harvest in December. It yields four per cent over the local, bulk. Acre yield 1,800 lb. *Grain size*: L—9·1 mm; B—3·1 mm; T—1·9 mm. *Glume colour*: Straw. *Rice*: White.

Agricultural Research Station, Maruteru (West Godavari District).

MTU 1. Bontha Akkullu.	Fourth week of November.	Isolated from *Akkulu*; grown over a very large area in the Godavari delta giving 20 per cent increased yield over ryots' bulk. It is cosmopolitan variety suited to varied conditions even to the saline and occasional submergible areas along the coast. Average yield per acre 2,880 lb. but has recorded up to 3,400 lb. *Grain size*: 8·0 mm; B—2·8 mm; T—2·0 mm. *Glume colour*: Dirty in furrows. *Rice*: White.
MTU 2. Potti Akkulu ..	Do.	Isolated from *Akkulu*; giving 16 per cent increased yield over ryots' bulk. It is a short growing type and hence suitable to rich lands where Bontha Akkulu may lodge. Though its rice is chalky white, its cooking quality is good. Average yield per acre 2,730 lb. but has recorded up to 3,500 lb. *Grain size*: L—7·9 mm; B—2·7 mm; T—1·9 mm. *Glume colour*: Dirty in furrows. *Rice*: White.

MTU 3. Potti Basangi ..	**Third week of October** ..	Isolated from *Basangi* giving 12 per cent increase over ryots' bulk. This variety is suited for rich heavily manured lands and for very early planted conditions before the end of June. It is a stiff and erect growing strain. This character is valuable for this variety, whose harvest usually gets caught in rains. Recommended for the Godavari delta. Yield per acre varies from 2,000 lb. to 4,500 lb. according to the time of planting and richness of the land, with an average of 3,665 lb. *Grain size*: L—8·1 mm; B—2·6 mm; T—2·0 mm. *Glume colour*: Straw. *Rice*: White.
MTU 4. Podha Basangi ..	**Fourth week of October** ..	Isolated from *Basangi*, giving nine per cent increased yield over ryots' bulk but is one week later than Potti Basangi and is suitable to areas of average fertility and indifferent water-supply and is fit for somewhat late planted conditions. It is recommended for the upland areas of the Godavari, Krishna and Guntur districts. Yield per acre 3,000 lb. to 4,000 lb. with an average of 3,394 lb. *Grain size*: L—8·8 mm; B—2·6 mm; T—2·0 mm. *Glume colour*: Dull straw. *Rice*: Red.
MTU 5. Bontha Krishna-katukulu.	**Early in first week of December.**	Isolated from *Krishnakatukulu* the major variety of West Godavari especially in the upper delta. Gives 12 per cent over ryots' bulk. Average yields 2,800 lb. but has recorded a maximum yield of 3,400 lb. per acre on an average. *Grain size*: L—7·8 mm; B—2·6 mm; T—1·8 mm. *Glume colour*: Straw with purple tip at end. *Rice*: White.
MTU 6. Potti Atragada ..	Do.	Isolated from *Atragada* of Godavari Delta. Yields 16 per cent over ryots' bulk. It is suitable to low-lying areas where water stagnates and does not drain easily. Its short habit helps to keep the crop erect. Rice is esteemed for its nutritive value. Average yield per acre 2,530 lb. *Grain size*: L—7·9 mm; B—2·0 mm; T—2·0 mm. *Glume colour*: Dirty in furrows. *Rice*: White.
MTU 7. Gutti Kusuma ..	Second week of December.	Isolated from *Gutti Kusuma*, the major variety grown under the Krishna irrigation system. Yields 16 per cent over the ryots' bulk. The strain does not lodge and is non-shedding. Also stands to some extent insufficient water supply during the growth period and yields up to a maximum of 3,500 lb. per acre in delta soils with an average yield of 2,660 lb. *Grain size*: L—6·6 mm; B—2·7 mm; T—2·0 mm. *Glume colour*: Straw. *Rice*: White.
MTU 8. Vanki sannam ..	Do.	Isolated from *Vanki sannam* giving 10 per cent increase over the ryots' bulk. This strain is conspicuous dark green appearance in growth. It scores over the local in its shedding and setting quality. The size is somewhat coarser than the local. *Grain size*: L—8·7 mm; B—2·5 mm; T—1·9 mm. *Glume colour*: medium gold. *Rice*: White.

Agricultural Research Station, Maruteru (West Godavari District)—cont.

Number and name of strain. (1)	*Normal time of harvest.* (2)	*Other particulars.* (3)
MTU 9. Garikasannavari.	120 days	Isolated from *Garikasannavari* grown over a 30 per cent of the area in the Godavari delta for the 'Dalwa' season between January-April yielding 18 per cent. over the ryots' bulk. It stands early planting better than *Nallarlu* and grows fairly well in newly reclaimed, coastal '*Parrah*' lands. In the first crop season a seed crop is generally taken between June to October for use in the next '*Dalwa.*' It is recommended for cultivation in Cuddapah and Tiruchirappalli districts where a crop is taken between December-May. Yields on an average 2,350 lb. per acre in the '*Dalwa*' season. *Grain size*: L—8·5 mm ; B—2·9 mm ; T—2·0 mm. *Glume colour*: Straw with purple tip a rice white.
MTU 10. Sannakrishna Katukulu.	Fourth week of November.	Isolated from *Krishnakatukulu*, one of the major varieties of West Godavari. As the name would indicate, the strain is finer and fetches four to eight annas per bag more than MTU 5. (*Bontha Krishnakatukulu*). It does not lodge and is well adapted to rich high level lands. Average yield 2,800 lb. but has recorded up to 3,200 lb. per acre. *Grain size*: L—7·5 mm ; B—2·3 mm ; T—1·7 mm. *Glume colour*: Straw with purple tip. *Rice*: White.
MTU 11. Konamani	Early in first week of December.	Isolated from *Konamani*, giving 30 per cent increase in yield. It is grown in both Krishna and Godavari deltas and in marginal lands of Collair lake. It is able to grow under deep water conditions, provided the crop is not completely submerged. Rice is esteemed for its nutritive value. Average yield per acre 3,000 lb. *Grain size*: L—8·1 mm ; B—3·0 mm ; T—2·0 mm. *Glume colour*: Dull straw. Rice: Brownish.
MTU 12. Pedda Atragada.	Second week of December.	Isolated from *Pedda Atragada* grown in Krishna delta. It is suitable for low-lying areas. As the name indicates, it is longer in duration than MTU 6 (Potti Atragada) or MTU 14 (Bontha Atragada) by about two weeks. Its rice is esteemed by the delta people and retained for home consumption. Average yield per acre 2,500 lb. but has reached a maximum of 3,500 lb. *Grain size*: L—8·2 mm ; B—2·8 mm ; T—2·1 mm. *Glume colour*: Dark dirty in furrows. *Rice*: White.
MTU 13. Delhi Bhogam ..	Do.	Isolated from *Delhi Bhogam* or otherwise known also as *Vankisannam*. This is suitable to well drained soils of the higher delta It yields as high as MTU 8. (Vankisannam and possesses the required fineness of size for the export market. *Grain size*: L—8·2 mm ; B—2·2 mm ; T—1·7 mm. *Glume colour*: Light gold. *Rice*: White.

MTU 14. Bontha Atragada.	Early in first week of December.	Isolated from Atragada of the Godavari delta, its thick straw and vigorous growth are the salient features. Does not lodge when other varieties lodge. Has a profuse characteristic, yellow vegetation. It is suitable for ill-drained lands at the tail-end of canals. Yields 9 per cent higher than MTU 6. (*Potti Atragada*). Average yield 2,680 lb. per acre. *Grain size*: L—7·9 mm.; B—2·7 mm.; T—2·0 mm. *Glume colour*: Dirty in furrows. *Rice*: White.
MTU 17. Kodibudama ..	Middle of October ..	This is a bulk of four cultures yielding 14 to 22 per cent over the local isolated from *Kodi Budama*, a variety grown in the heavy black soils of Godavari, Krishna and Guntur districts, under rainfed conditions between the months of June to October, when a rainfall of 20 to 30 inches is received. Under favourable rainfall conditions yields 1,500 lb. grain per acre. *Grain size*: L—8·2 mm.; B—2·9 mm.; T—2·1 mm. *Glume colour*: Dull straw. *Rice*: Red.
MTU 18. Kodi Jillama ..	End of October	This is a bulk of three cultures yielding on the average 9 per cent over the unselected local, isolated from *Kodi Jillama* a variety grown in the heavy soils of Godavari, Krishna and Guntur districts purely under rainfed conditions. It is a fortnight later than MTU 17 (*Kodi budama*). Under favourable rainfall conditions, yields 1,500 lb. grain per acre. *Grain size*: L—8·2 mm.; B—2·9 mm.; T—2·0 mm. *Glume colour*: Dull straw. *Rice*: Red.
MTU 21. Prayaga (Culture 3660).	Early in first week of December.	This is a pure line selection from the *Prayaga* variety. Common in the low level areas with water stagnation. It is a green throughout vigorous growing type and has recorded up to 21 per cent increase in yield over the ryots' bulk, on the station and from 10 to 18 per cent higher yields in the district trials. *Grain size*: L—8·2 mm.; B—2·6 mm.; T—2·1 mm. *Glume colour*: Ripening straw. *Rice*: White.

Rice Research Station, Buchireddipalem (Nellore District).

BCP 1. Molakolukulu (2555).	190	It stands late planting like 2202 (BCP 2) and is a week later than local. The grain is fine. The rice is of better quality with no abdominal white and gets a premium over the culture Molakolukulu 2202 (BCP 2). It is disease-resistant and in Nellore and Kovvur taluks it has spread well and has yielded up to 4,000 lb. per acre. It has a better tillering capacity than Molakolukulu 2552. Average yield 2,500 lb. per acre. *Grain size*: L— mm.; B— mm.; T— mm. *Glume colour*: Medium dirty. *Rice*: White.

Rice Research Station, Buchireddipalem (Nellore District)—cont.

Number and name of strain. (1)	*Normal time of harvest.* (2)	*Other particulars.* (3)
BCP 2. Molakolukulu (2202).	190	Isolated from *Molakolukulu*, mostly cultivated in Nellore district and known widely as *Nellore samba*. It adapts itself better than other cultures for late-planted conditions in August and September. It is a hardy type, gives a higher proportion of rice to paddy by weight and is resistant to salinity, paddy blast and drought. Its abdominal white leads to breakage in raw milling and hence it is more suitable for par-boiled rice. It is largely grown in the upland taluks of Nellore district, like Venkatagiri, Atmakur, Kavali and Kandukur. In years when paddy blast occurs, it has given as much as 15 to 50 per cent higher yields than local and has yielded 2,500 lb. per acre. *Grain size*: L— mm.; B— mm.; T— mm. *Glume colour*: Dark dirty. *Rice*: White.
BCP 3. Atragada (Culture 409).	160	This is a pure-line selection from variety *Atragada* that is grown in the high-level areas of Nellore district. It is a robust variety. It has given from 10 to 30 per cent increased yields over the local on the station and up to 40 per cent in the district. It is green throughout type. *Grain size*: L—8·2 mm.; B—2·7 mm.; T—2·1 mm. *Glume colour*: Dark furrows ripening brown. *Rice*: White.
BCP 4. Pishanam (Culture 1283).	180	This is a pure line selection from the high quality *Pishanam* variety which was once popular in Nellore, but now restricted due to its susceptibility to blast. It has given increased yields of 10 to 40 per cent on the station and up to 20 per cent in district trials. It is a green throughout robust variety with a bunched earhead. *Grain size*: L—7·5 mm.; B—2·4 mm.; T—1·9 mm. (fine). *Glume colour*: Straw. *Rice*: White with good quality.
BCP 5. Sannavadlu (Culture 1435).	180	This is a pure line selection from the *sannavadlu* variety commonly grown under tanks. It is drought-resistant and is a robust variety with bunched earheads. It has given varying results on the station, but has done well in the district. It is a green throughout type. *Grain size*: L—8·4 mm.; B—2·5 mm.; T—2·0 mm. *Glume colour*: Straw. *Rice*: White.

Agricultural Research Station, Palur (South Arcot District).

PLR 1. Garudansamba ..	170	Isolated from Local *Garudansamba*. It gave an average increase of 20 per cent over, the ryots' bulk. The plant is tall, with good tillering habit. The ear is fairly compact and heavy with medium size of grain. It is very popular in South Arcot district. As raw and par-boiled rice it cooks and tastes well. Average acre yield is 4,200 lb. *Grain size*: L—8·4 mm.; B—3·2 mm.; T—2·1 mm. *Glume colour*: Dirty in furrows. *Rice*: White.

PLR 2. Chitrakali ..	105	Isolated from *Chitrakali* giving 30 to 50 per cent, increased yield over ADT 12 (*Chitrakali*). The plant is fairly tall with good tillering habit. This is popular with South Arcot ryots. This strain grown in '*Navarai*' season in Chingleput district has given good yields. Average yield per acre is 3,100 lb. *Grain size*: L—8·4 mm.; B—3·2 mm.; T—2·1 mm. *Glume colour*: Straw; *Rice*: White.
	Agricultural Research Station, Ambasamudram (Tirunelveli District.)	
ASD 1. Karsamba red ..	115	This strain (culture 1055) is isolated from the *Karsamba red*, giving 21 per cent, increased yield over the ryots' bulk and 12 per cent, over CO 9 (Karsamba red) a strain already under distribution. This strain grows tall and tillers well with good quality of straw. It has also a better percentage of rice to paddy than the local karsamba red, the increase being 2·09 per cent, by weight and 0·89 per cent, by volume. Though coarse it is held in high esteem and it fetches as good a price as fine white rice. The acre yield ranges from 3,600 lb. to 4.500 lb. under well manured condition. *Grain size*: L—8·0 mm.; B·4·1 mm.; T—2·1 mm.; *Glume colour*: Dull straw. *Rice*: Red.
ASD 2. Karsamba white	110	This strain (culture 1946) isolated from *Karsamba white* is grown in the first crop (Kar season) and gives ten per cent increased yield over the ryots' bulk. It has attractive showy panicles with a finer size of grain than the local bulk. It is of non-shedding nature. Its flour is very much reputed for its suitability in the preparation of high quality cakes '*Idlis*'. The acre yield ranges from 3.500 lb. to 4,000 lb. *Grain size*: L—7·6 mm; B—3·1 mm.; T—2·1 mm.; *Glume colour*: Dull straw. *Rice*: Red.
ASD 3. Veedhivadangan	130	This strain (culture 2535) is isolated from *Veedhivadangan* bulk and gives 15 per cent, increased yield over the ryots' bulk. It is a very coarse, long duration variety grown largely in Tenkasi taluk of the Tirunelveli district and is reported to be drought resistant, and non-lodging in habit. The acre yield ranges from 3,000 lb. to 3,500 lb. *Grain size*: L—8·3 mm.; B—3·1 mm.; T—2·1 mm. *Glume colour*: Full dirty in furrows. *Rice*: Red.
ASD 4. Kuruvaikalayan.	S—First week of September, H—First week of January and D—135 days.	This strain (culture 21) is isolated from *Kuruvaikalayam* and gives 35 per cent, increased yield over the ryots' bulk. It is a coarse, drought resistant strain suitable to be sown broadcast in September with the advent of pre-monsoonic showers of the north-east monsoon. It is grown as a dry crop for about two months and thereafter treated as a swamp paddy. It is grown largely under the ayacuts of rainfed tank areas, where rainfall is precarious and the supply of water insufficient to take a long duration crop. The acre yield ranges from 2,000 lb. to 2,500 lb. *Grain size*: L—8·5 mm.; B—3·3 mm. T—2·3 mm. *Glume colour*: Full dirty in furrows. *Rice*. Red.

Agricultural Research Station, Ambasamudram (Tirunelveli District)—cont.

Number and name of strain. (1)	*Normal time of harvest.* (2)	*Other particulars.* (3)
ASD 5. Karthigasamba ..	S—15th October, H—2nd week of March and D—135 days.	This strain (culture 3224) is isolated from *Karthigasamba* bulk and gives 15 per cent, increased yield over CO2 (Karthigasamba) strain already under distribution. It is taller than CO 2 with a finer grain and gives a higher hulling percentage of rice to paddy. It adapts itself better than other varieties for late planted conditions of November. The strain is cosmopolitan in nature and has done very well under different conditions obtaining in Ramanathapuram and South Arcot districts. Its yield ranges from 3,000 lb. to 4,000 lb. per acre. *Grain size* : L—7·6 mm. ; B—2·5 mm. ; T—1·9 mm. ; *Glume colour*: Straw. *Rice* ; White.
ASD 6. Anaikomban ..	S—1st September, H—3rd week of February and D—170 days.	This strain is isolated from *Anaikomban* (Culture 2927). Gives an increased yield of 12 per cent, over local and CO 8 a strain already released. Non-shedding. Cooking quality is reported to be better than CO 8. Under well-manured conditions, its yield ranges from 3,500 lb. to 4,000 lb. per acre. *Grain size* : L—8·6 mm.; B—2·6 mm.; T—1·9 mm. *Glume colour* : Straw. *Rice* : White.
ASD 7. Karsamba Red ..	S—1st June, H—3rd week of September and D—110 days.	This strain is released from *Karsamba Red* (culture No. 1296) CO 9. Earlier and gives 12 per cent, increased yield over local. Non-lodging. size of grain bold. Popular in the tail-end valley of the Tirunelveli district. *Grain size* : L—8·0 mm.; B—3·3 mm., T—8·1 mm. *Glume colour* ; Düll straw. *Rice* : Red.

NOTE.—S—Sowing time ; H—Time of harvest ; D—Duration in days.

Agricultural Research Station, Aduthurai (Tanjore District).

ADT 1. Red Sirumani ..	175	Isolated from *Red Sirumani*. Grown in Shiyali, Mayavaram, Nannilam and Mannargudi, Tiruthuraipundi of Tanjore district and parts of South Arcot. Mainly exported as par-boiled rice to Ceylon. Yields 16 per cent, over the local bulk. Gives an acre yield of 3,000 lb. *Grain size* : L—6·4 mm ; B—3·1 mm.; T—2·1 mm. *Glume colour* : Dirty in furrows. *Rice* : White.
ADT 2. White Sirumani ..	165	Isolated from white *Sirumani*. Grown in all the taluks where *Red Sirumani* is grown and in Cauvery Mettur Project areas. Consumed by richer classes, grown as a *Thaladi* crop. It matures much earlier (150 days) than the Nellore samba crop. Gives 10 per cent, increase over ryots' bulk and an acre yield of 2,800 lb. *Grain size* : L—5·8 mm.; B—2·9 mm.; T—2·0 mm. *Glume colour* : Straw. *Rice* : White.

ADT 3. Kuruvai	95	Isolated from *Kuruvai*. Grown in Tanjore district and parts of Nellore, Chingleput, North Arcot, South Arcot, Tiruchirappalli, Salem, Coimbatore, Madurai districts. It gives 12 per cent, increase over ryots' bulk. It is noted for its earliness. Yields 3,640 lb. per acre. *Grain size* : L—7·7 mm.; B—3·0 mm.; T—2·0 mm. *Glume colour* : Dirty in furrows. *Rice* : White.
ADT 4. Kuruvai	100	Isolated from *Kuruvai*. Grown extensively in several taluks of Tanjore district and parts of Tiruchirappalli, South Arcot, Salem, Coimbatore and Madurai districts. It gives 12 per cent, increase over ryots' bulk. Yields 3,700 lb. per acre. *Grain size* : L—8·2 mm.; B—2·8 mm.; T—2·0 mm. *Glume colour* : Dirty in furrows. *Rice* : White.
ADT 5. Nellore samba ..	180	Isolated from *Nellore samba* (big grained). Grown in Tanjore, Papanasam, Mannargudi, Arantangi, Pattukkottai of Tanjore district and parts of Tiruchirappalli, Nellore, South Arcot, Coimbatore and Tirunelveli districts. Exported to Salem and Coimbatore markets. Increase over ryots' bulk is 25 per cent, Yields 2,800 lb. per acre. *Grain size* : L—8·1 mm.; B—3·1 mm.; T—2·9 mm. *Glume colour* : Dirty in furrows. *Rice*: White.
ADT 6. Red Ottadan ..	220	Isolated from *Red Ottadan*. Grown in most of the taluks of Tanjore and Chidambaram taluk in South Arcot district. Increase over ryots' bulk is 13 per cent, Yield per acre, 2,000 lb. *Grain size* : L—7·7 mm.; B—3·0 mm.; T—2·0 mm. *Glume colour* : Dark colour ; Dark gold. *Rice* : White.
ADT 7. White Ottadan ..	220	Isolated from *White Ottadan*. This is also used as 'Udu'. Increase over ryots' bulk is 13 per cent. Yields per acre 2,000 lb. *Grain size* : L—7·6 mm.; B—3·0 mm.; T—2·0 mm. *Glume colour* : Straw. *Rice* : White.
ADT 9. Poonkar	120	Isolated from *Poonkar*. Grown in Tanjore, Kumbakonam, Nannilam, Nagapatinam and Pattukkottai taluks of Tanjore district and parts of Tiruchirappalli, Chingleput, North Arcot and South Arcot districts. Exported largely to Salem market. It gives an increase of 15 per cent, over ryots' bulk. Yields 4,600 lb. per acre. *Grain size* : L—8·2 mm.; B—2·8 mm.; T—1·9 mm. *Glume colour* : Straw. *Rice* : White.
ADT 10. Korangusamba	165	Isolated from *Korangusamba*. Grown in all taluks of Tanjore. Mostly exported to Central districts as par-boiled rice. Increase over ryots' bulk is 9 per cent. Yields 3,900 lb. per acre. *Grain size* : L—7·2 mm.; B—3·0 mm.; T—1·9 mm. *Glume colour* : Dirty in furrows. *Rice* : White.
ADT 11. Nellore samba ..	175	Isolated from *Nellore samba* (Small grained). Grown in all taluks of Tanjore, Tiruchirappalli and parts of Chingleput, Salem, Coimbatore, Madurai and Tirunelveli districts. Increase in yield over ryots' bulk is 6 per cent. Yield per acre 3,400 lb. *Grain size* : L—7·4 mm.; B—2·8 mm.; T—1·9 mm. *Glume colour* : *Dirty* in furrows. *Rice* : White.

Agricultural Research Station, Aduthurai (Tanjore District)—cont.

Number and name of strain. (1)	*Normal time of harvest.* (2)	*Other particulars.* (3)
ADT 12. Chitrakali ..	115	Isolated from *Chitrakali*. Grown largely in Tanjore and Papanasam of Tanjore district, parts of Tiruchirappalli, North Arcot, South Arcot and Chingleput districts. Exported mostly to Salem market. This can stand irregular water-supply. Gives an increase of nine per cent, over ryots' bulk and yields 3,500 lb. per acre. *Grain size* : L—8·7 mm. ; B—2·9 mm. ; T—2·0 mm. *Glume colour* : Straw with granular dirty. *Rice* : White.
ADT 13. Sanna samba ..	160	Isolated from *Sannasamba*. Grown in Kumbakonam, Mayuram and Mannargudi of Tanjore district and parts of Tiruchirappalli upland taluks. Increase over local is seven per cent. Acre yield is 3,800 lb. *Grain size* : L—7·8 mm. ; B—2·6 mm. T—1·9 mm. *Glume colour* : Straw. *Rice* : White.
ADT 14. Vellaikar ..	115	Isolated from *Vellaikar*. Grown chiefly in Kumbakonam and Papanasam of Tanjore district, parts of Salem, Tiruchirappalli and South Arcot districts. Gives nine per cent, increase over ryots' bulk and yields 4,300 lb. per acre. *Grain size* : L—8·8 mm. ; B—2·9 mm. ; T—2·0 mm. *Glume colour* : Straw with granular dirty. *Rice* : White.
ADT 16. Konakuruvai ..	115	Isolated from *Konakuruvai*. Grown in Kumbakonam, Mayuram, Sirkali, Nannilam, Nagapattinam and Mannargudi. Gives 25 per cent, over ryots' bulk and yielded 3,600 lb. per acre. *Grain size* : L—7·7 mm. ; B—1·9 mm. ; T—1·5 mm. *Glume colour* : Light gold. *Rice* : White.
ADT 17. Muthusamba ..	165	Isolated from *Muthusamba*. Grown mainly in parts of South Arcot district. This is a variety with the coarsest bold type of grain. Increase over local is 10 per cent. Acre yield is 3,700 lb. *Grain size* : L—7·8 mm. ; B—3·4 mm. ; T—2·2 mm. *Glume colour* : Dirty in furrows. *Rice* : White.
ADT 18. Vellai Kuruvai	125	Isolated from *Vellai Kuruvai*. Grown mainly in Musiri and Karur taluks of Tiruchirappalli district and Namakkal of Salem district. Increase over local is 12 per cent. Acre yield 3,600 lb. *Grain size* : L—8·1 mm. ; B—3·0 mm. ; T—2·0 mm. *Glume colour* : Straw. *Rice* : White.
ADT 19. Sarapalli ..	109	Isolated from *Vellai Kuruvai*. Grown mainly in Musiri and Karur taluks of Tiruchirappalli district, gives an increased yield of 19 per cent, over ryots' bulk. Average acre yield 3,600 lb. *Grain size* : L—8·1 mm. ; B—3·0 mm. ; T—2·0 mm. *Glume colour* : Straw. *Rice* : White.

ADT 21. Vadansamba (Tanjore).	150	Isolated from *Vadansamba* of Tanjore district. Grown in Sirkali, Mayuram and other coastal taluks of Tanjore district; gives an increased yield of 16 per cent, over local. The grain is coarse. *Grain size*: L—8·5 mm.; B—3·0 mm.; T—2·0 mm. *Glume colour*: Dirty in furrows. *Rice*: Red. Withstands certain amount of salinity and deepwater conditions.
ADT 22. Vadansamba ..	155	Isolated from *Vadansamba* of North Arcot district, a variety cultivated under semi-dry conditions. It is sown dry during July-August and later treated as a swamp paddy after the break of north-east monsoon. It is recommended for cultivation in the semi-dry areas in the Central, Chingleput and South Nellore and near South Arcot districts. It has recorded an increase of 24 per cent, over local. *Grain size*: L—8·1 mm.; B—2·6 mm.; T—1·9 mm. *Glume colour*: Dull straw. *Rice*: Brownish white.
ADT 23. Kullankar ..	120	Isolated from *Kullankar* of Sirkali and Chidambaram taluks. This is a coarse variety which stands slight amount of salinity and is grown between December-January to April-May. It has given per cent, increase over ryots' bulk. *Grain size*: L—8·0 mm; B—3·1 mm.; T—2·2 mm. *Glume colour*: Dirty in furrows, ripening brown, *Rice*: Red.

The Agricultural Research Station, Pattambi (South Malabar District).

PTB 1. Aryan	145	Isolated from *Aryan*, cultivated in the first crop season in double crop wet lands in South Malabar. It has given an increase of 15 per cent, over ryots' bulk and recorded a maximum of 3,000 lb. of grain per acre with an average of 2,500 lb. It is popular in Walluvanad and Ernad taluks of Malabar and is recommended for Udipi and Coondapoor taluks in South Kanara, in place of Halliga. *Grain size*: L—8·2 mm.; B—2·9 mm.; T—2·0 mm. *Glume colour*: Dirty in furrows. *Rice*: Red.
PTB 2. Ponnaryan ..	135	Isolated from *Ponnaryan*, a first crop variety usually grown in *Palliyal* areas in South Malabar. This strain is recommended for both single and double crop lands. This strain has given an increase of 15 per cent, over ryots' bulk seed and recorded a maximum yield of 2,500 lb. per acre, in Palliyal areas with an average of 2,250 lb. It is also recommended for cultivation in the Udipi and Coondapoor taluks of South Kanara district. *Grain size*; L—8·8 mm.; B—3·0 mm.; T—2·0 mm. *Glume colour*: Dirty in furrows. *Rice*: Red.
PTB 3. Eravapandy ..	128	Isolated from *Eravapandy*, cultivated in Walluvanad taluk. It is the earliest of the second crop varieties. It is recommended for areas where water scarcity is felt in the latter half of January and early February. It has given eight per cent, increase over the local and an average yield of 1,800 lb. per acre. *Grain size*: L—8·6 mm.; B—2·8 mm.; T—2·0 mm. *Glume colour*: Dirty in furrows. *Rice*: Red.

Agricultural Research Station, Pattambi (South Malabar District)—cont.

Number and name of strain. (1)	*Normal time of harvest.* (2)	*Other particulars.* (3)
PTB 4. Vellari	140	Isolated from *Vellari*. A late maturing second crop variety yielding 22 per cent, over ryots' bulk. It is the heaviest yielder of the second crop varieties, provided the water supply is sufficient till the end of January. It has given a maximum yield of 2,200 lb. with an average of 2,050 lb. per acre. This is also recommended for the South Kanara district, as it yields better than *Athikraya*. *Grain size :* L—8·1 mm.; B—3·1 mm.; T—2·1 mm. *Glume colour.* Dull straw; *Rice :* Red.
PTB 5. Velutharikayama.	140	Isolated from *Velutharikayama*, cultivated in South Malabar in Iruppugal lands. It is like PTB 1 (Aryan), recommended to lands commanding a good water-supply. It is the heaviest yielder of all first crop varieties. It has given an increase of 15 per cent, in yield over the local seed and recorded an average yield of 2,360 lb. It is also recommended for the northern taluks of South Kanara district. *Grain size :* L—8·4 mm.; B—2·0 mm.; T—2·0 mm. *Glume colour :* Dull straw with granular [illegible] patches. *Rice :* Red.
PTB 6. Athikraya ..	145	Isolated from *Athikraya*, the chief second crop variety of South Kanara. The strain grows taller than the local and yields 18 per cent, over the local seeds. The maximum yield per acre was 2,000 lb. and its average is 1,860 lb. *Grain size :* L—8·0 mm.; B—3·1 mm.; T—2·0 mm. *Glume colour ;* Dark dirty in furrows. *Rice :* Red.
PTB 7. Parambuvattan ..	125	Isolated from *Parambuvattan*, an awned black glumed variety, cultivated in high level *Palliyals* in Walluvanad taluk. This variety can stand irregular water-supply during the growing period and tolerates somewhat saline conditions in coastal areas. The strain gives an increase of 13 per cent, over ryots' bulk and recorded a maximum yield of 2,350 lb. per acre in high level *Palliyals* with an average yield of 2,100 lb. *Grain size :* L.—8·0 mm.; B—2·8 mm.; T—2·0 mm. *Glume colour :* Ripening black. *Rice :* Red.
PTB 8. Chuvannari Thavalakkannan.	130	Isolated from *Thavalakkannan*, a popular variety in Malabar and South Kanara. The strain matures a week earlier and gives an increased yield of 17 per cent, over the local. It is recommended for areas where an early first crop is required. It has given a maximum yield of 2,500 lb. with an average yield of 2,200 lb. per acre. *Grain size :* L—7·3 mm.; B—2·9 mm.; T—2·0 mm. *Glume colour :* Dull straw with purple tip and end. *Rice :* Red.

PTB 9. Veluthari. Thavalakkannan.	145	Isolated from *Thavalakkannan*. Though the strain is of the same duration as the local it grows erect and tall with stiff straw and is non-shedding. It is becoming increasingly popular. The strain yielded 13 per cent, over the local and has given a maximum yield of 2,900 lb. with an average yield of 2,300 lb. per acre. *Grain size* : L—7·4 mm.; B—2·9 mm.; T—2·0 mm. *Glume colour* : Dull straw with purple tip and end. *Rice* : White.
PTB 10. Thekkancheera ..	100 ..	*Strain for "Punja" or third crop. (Autumn, winter and spring rice.)* Isolated from *Thekkancheera*, a short duration variety grown in all the three seasons —first, second and third crop seasons—but largely grown in the third crop season when it is at its best, yielding over 2,100 lb. per acre. It is also observed in some tracts to stand irregular water-supply. *Grain size* : L—8·1 mm.; B—2·9 mm.; T—2·0 mm. *Glume colour* : Dirty in furrows. *Rice* : White.
PTB 11. Halliga	145 ..	Isolated from *Halliga*, a first crop variety of major importance in Coondapoor and portions of Udipi taluk of South Kanara district. The strain yielded an average of nine per cent, over the ryots' bulk. The average yield is 2,130 lb. per acre. *Grain size* : L—5·0 mm.; B—2·8 mm.; T—2·0 mm. *Glume colour* : Straw. *Rice* : White.
PTB 12. Chitteni	140 ..	Isolated from *Chitteni* of South Malabar. This is grown chiefly in Walluvanad, Palghat, Ernad and Ponnani taluks. This differs in all respects from the Chitteni of North Malabar. It has recorded an increase of 12·7 per cent, over the ryots' bulk. This variety sown by the end of August comes to harvest by the second week of January. An acre yield of 2,000 lb. is obtained in normal seasons. *Grain size* : L—7·7 mm.; B—2·9 mm.; T—2·0 mm. *Glume colour* : Dirty furrows, ripening black. *Rice* : Red.
PTB 13. Kayama ..	135 ..	Isolated from *Kayama*, a popular first crop variety of South Kanara especially in the Southern taluks. The strain yielded 21 per cent over the ryots' bulk. An acre yield of 2,210 lb. may be expected in a normal season. *Grain size* : L—7·3 mm.; B—3·0 mm.; T—1·8 mm. *Glume colour* : Dull straw. *Rice* : Red.
PTB 14. Mascathi ..	130 ..	Isolated from *Mascathi*, a popular white riced variety of Mangalore taluk. The strain recorded an increase of 19 per cent, over local in the trial in district trials. The rice is considered good for making beaten rice and once commanded an export market. Average yield 2,500 lb. *Grain size* : L—8·2 mm.; B—2·7 mm.; T—1·8 mm. *Glume colour* : Straw. *Rice* : White.

Agricultural Research Station, Pattambi (South Malabar District)—cont.

Number and name of strain. (1)	*Normal time of harvest.* (2)	*Other particulars.* (3)
PTB 15. Kavungin-poothala (Late).	165	Isolated from *Kavunginpoothla*, a variety suitable for lands known as "Karinkora" in Malabar and "Petla" in South Kanara, which are subjected to inundation, during the south-west monsoon months of June-August. Sowing is done in August and planting in September. This variety tillers well and grows tall, with stiff straw, non-lodging. The crop with its good emergence and attractive long drooping heads is a sight in itself. It is also recommended for areas normally planted with long duration samba, that gets inundated in October and November. Reports from Tanjore and Chidambaram are encouraging. The strain gave 18 per cent, higher yield than unselected bulk. An acre yield of 3,000 lb. was obtained under Malabar conditions. *Grain size*: L—7·9 mm; B—2·3 mm; T—1·7 mm. *Glume colour*: Straw. *Rice*: White.
PTB 16. Kavungin-poothala. (Early.)	155 . ..	This strain, but for its earliness, is similar in all its characters to PTB 15 (Kavungin-poothala PTB 15). It is therefore recommended for places like the Northern Circars where an early strain is desirable. *Grain size*: L—8·2 mm.; B—2·2 mm.; T—1·7 mm. *Glume colour*: Straw. *Rice*: White.
PTB 17. Jeddu Halliga ..	150	It is a strain isolated from '*Jeddu Hallinga*' variety cultivated in Coondapoor and portions of Udipi taluk of South Kanara district during the first crop season. It is usually sown in the first week of May and harvested during the middle of October. The variety is suitable for rich heavily manured and early planted conditions. Straw is stiff erect and comparatively non-lodging. An average increase of 22·7 per cent, over the ryots' bulk has been recorded in this station with an average yield of 2,110 lb. *Grain size*: L—8·7 mm.; B—3·1 mm.; T—2·2 mm. *Glume colour*: Dull straw with granular brown patches. *Rice*: Red.
PTB 18. Eravapandy ..	130	This has recorded an average increase of 23·4 per, cent, over PTB 3 (Eravapandy). *Grain size*: L—8·6 mm; B—2·8 mm; T—2·2 mm. *Glume colour*: Dirty in furrows. *Rice*: Red.
PTB 19. Athikraya ..	145	It is a strain isolated from *Athikraya*, the chief second crop variety of South Kanara. The strain has recorded an increase of 16 per cent, over PTB 6 (Athikraya) on the station... It is sown about the middle of September or early in October and is harvested late in January or early in February. *Grain size*: L—8·0 mm.; B—3·0 mm.; T—2·0 mm. *Glume colour*: Ripening brown. *Rice*: Red.

PTB 20. Vadakkan ..	120 ..	.. Isolated from *Chitteni* of North Malabar, a popular second crop variety different from PTB 12 (Chitteni of South Malabar). An average increase of 44·7 per cent over the ryots' bulk was recorded. *Grain size*: L—8·0 mm.; B—2·9 mm.; T—2·0 mm. *Glume colour*: Ripening into tawny in furrows. *Rice*: Red.
PTB 21. Thekkan ..	130 ..	.. Popular second crop variety of Walluvanad and Ernad taluks of Malabar district. Isolated from *Thekkan*. Given special preference due to good cooking quality. Sown in early September, comes to harvest during the middle of January. Three years' average yield increase is 14 per cent over ryots' standard. *Grain size*: L—8·5 mm.; B—3·0 mm.; T—2·0 mm. *Glume colour*: Green with dark furrows ripening brown. *Rice*: Red.
PTB 22. Veluthavattan ..	110 ..	.. This is a pure line selection from the short duration variety *Veluthavattan* common in the coastal areas. It is a robust type with light green foliage, and has recorded an increased yield up to 25 per cent over the local type at the station and up to 20 per cent in district trials. *Grain size*: L—7·4 mm.; B—3·0 mm.; T—1·9 mm. *Glume colour*: Green, ripening straw. *Rice*: Red.
PTB 23. Cheriya Aryan ..	100 ..	.. This is a pure line selection from the variety *Cheriya Aryan*, common on the lighter type of Malabar soils. It is a quick growing type with an increase in yield of 20 per cent at the station and up to 40 per cent in district trials. *Grain size*: L—8·1 mm.; B—3·0 mm.; T—2·0 mm. *Glume colour*: Dirty in furrows, ripening brown with purple tip. *Rice*: Red.
PTB 24. Chuvannavattan.	105 ..	.. Selection from local type of same name; short duration; common on sandy soils near coast. Gave up to 15 per cent in station and up to 20 per cent over local in district trials. *Grain size*: L—8·5 mm.; B—3·2 mm.; T—2·1 mm. *Glume colour*: Dirty in furrows, ripening brown, no purple tip. *Rice*: Red.
PTB 25. Thonnooran ..	100 ..	.. This is grown both as a dry and a wet crop. It is a rank growing, vigorous, green-throughout type. Recorded up to 20 per cent over local at station and up to 25 per cent in district trials. *Grain size*: L—8·8 mm.; B—3·2 mm.; T—2·2 mm. *Glume colour*: Straw coloured. *Rice*: Red.
PTB 26. Chen Kayama ..	135 ..	.. Common in broadcast areas of Palghat taluk, which are usually infested with wild rice. It has a purplish foliage and hence is easily distinguishable from wild rice plants even in young stages, so that weeding out of wild rice plants is easy. Gave up to 11 per cent increase over local on the station and up to 29 per cent in district trials. *Grain size*: L—7·7 mm.; B—3·0 mm.; T—2·0 mm. *Glume colour*: Green with purple tip. *Rice*: Red.
PTB 27. Kodiyan ..	130 ..	.. A pure line selection from *Kodian* variety, common in the second crop lands of coastal areas. It is a short, vigorous growing type, which does not lodge. Gave up to 40 per cent increase at the station and 12 per cent over local in district trials. *Grain size*: L—8·2 mm.; B—3·2 mm.; T—2·0 mm. *Glume colour*: Green (straw) with purple tip. *Rice*: Red.

Paddy Breeding Station, Coimbatore.

Number and name of strain. (1)	*Normal time of harvest.* (2)	*Other particulars.* (3)
CO 1. Peria Kichili ..	First week of December ..	Isolated from GEB 24 (*Kichilisamba*) as a natural cross yielding 20 per cent over GEB 24. Possesses more or less the qualities of GEB 24. Only the rice is coarse and is a week later in duration. It is already popular in Coimbatore and Tiruchirappalli districts and is spreading in the Divi taluk in Krishna district. *Grain size* : L—8·5 mm. B—2·6 mm. ; T—1·9 mm. *Glume colour* : Straw. *Rice* : White.
CO 2. Poombalai or Karthigasamba.	Second week of December.	Isolated from *Poombalai*, grown in Sivagiri taluk of Ramanathapuram district. It adapts itself better than other varieties of late planted conditions in October-November. On an average it has recorded 8 per cent over ryots' bulk, and has given maximum yield of 4,800 lb. per acre. *Grain size* : L—7·5 mm. ; B—2·5 mm. ; T—1·9 mm. *Glume colour* : Straw. *Rice* : White.
CO 3. Vellaisamba ...	Do.	Isolated from *Vellaisamba* cultivated in Coimbatore yielding 9 per cent over ryots' bulk. It is becoming popular in South Kanara and Palghat taluk of Malabar for the second crop. It has yielded 4,000 lb. per acre in Central Farm. *Grain size* : L—8·4 mm. ; B—2·7 mm. ; T—2·0 mm. *Glume colour* : Straw. *Rice* : White.
CO 4. Anaikomban. (Gobichettipalayam).	Normal third week of January. Thaladi : third week of February.	Isolated from *Anaikomban*, cultivated in Gobichettipalayam taluk (Coimbatore) yielding 11 per cent over ryots' bulk. It is a tall-growing variety with coarse straw and grain. It is sought after for making '*Pori*' or '*Puffed rice*'. It is resistant to '*Paddy blast*'. It has given an acre yield of 3,700 lb. *Grain size* : L—8·6 mm. ; B—2·7 mm. ; T—2·0 mm. *Glume colour* : Dull straw. *Rice* : White.
CO 5. Chinnasamba ..	Third week of December.	Isolated from *Chinnasamba*, cultivated in Coimbatore. Yields 12 per cent over ryots' bulk. It responds to high manuring and yields about 3,500 lb. under average conditions. Rice is fine. *Grain size* : L—7·9 mm. ; B—2·6 mm. ; T—1·9 mm. *Glume colour* : Straw. *Rice* : White.
CO 6. Sadaisamba ..	First week of January ..	Isolated from *Sadaisamba*, a long duration variety grown on single crop lands where water-supply is available till January. It is a tall growing variety with good tillering. It has yielded 3,890 lb. per acre. *Grain size* : L—7·7 mm. ; B—2·8 mm. ; T—1·9 mm. *Glume colour* : Straw. *Rice* : White.
CO 7. Sadaisamba. (Gobichettipalayam).	Second week of December.	Isolated from *Sadaisamba* of Gobichettipalayam taluk. It tillers profusely and has yielded 4,100 lb. per acre. It is most popular in Tiruchirappalli district, where an increase of 10 per cent has been recorded. *Grain size* : L—7·9 mm. ; B—2·7 mm. ; T—1·9 mm. *Glume colour* : Straw. *Rice* : White.
CO 8. Tinnevelly Anaikomban.	Normal : second week of January. Thaladi : first week of February.	Isolated from *Anaikomban* of Tirunelveli, generally grown in '*Pishanam*' season. It is locally appreciated for its quality of rice and size of grain. Yields 17 per cent over ryots' bulk. It is recommended for the Tambraparni and Palghat taluk where *Anaikomban* is cultivated. Yields 3,200 lb. per acre. *Grain size* : L—8·8 mm. ; B—2·6 mm. ; T—1·9 mm. *Glume colour* : Straw. *Rice* : White.

CO 9. Karsamba Red ..	110	Isolated from *Karsemba red* grown in Tambaraparni basin in Tirunelveli district, yielding 14 per cent over local. This variety is held in high esteem in Tirunelveli. Yields over 3,000 lb. per acre. *Grain size* : L—7·4 mm. ; B—3·2 mm. ; T—2·2 mm. *Glume colour* : Dull straw. *Rice* : Red.
CO 10. Gobi Kar	120	Isolated from the '*Kar*' variety cultivated in Gobichettipalayam taluk, yielding 17 per cent over the local. This variety is recommended for areas under *Bhavani* irrigation. It is suitable for cultivation both in '*Kodai*' (April to September) and '*Navarai*' cold weather season (December-February). Rice is sought after for the preparation of 'Pori' or 'Puffed rice'. Average yield 2,400 lb. per acre. *Grain size* L–8. 1 mm ; B—2·9 mm. T-2. omm. ; *Glume colour* : Straw. *Rice* : White.
CO 11. Ayyansamba ..	Normal: second week of January. Thaladi: 2nd week of February.	Isolated from *Ayyansamba* or 'Davara' of Gobichettipalayam taluk yielding 13 per cent, over the ryots' seed. It is known for its fine quality. Grows taller than CO 8 (*Anaikomban*) and is liable to lodging under highly manured conditions. The grain has an attractive clean straw colour. *Grain size* : L—8·2 mm. ; B—2·6 mm. ; T—1·9 mm. *Glume colour* : Clean straw. *Rice* : White.
CO 12. Sendhinayagam ..	Normal: Third week of January. Thaladi: 3rd week of February.	Isolated from *Sendhinayagam*, grown in Ambasamudram taluk in Tirunelveli yielding 13 per cent over the ryots' seed. It is grown in the 'Pishanam' season, where water-supply is adequate till the end of February. Both grain and straw better than Anaikomban (CO 8). It has given an acre yield of 3,000 lb. *Grain size* : L—8·6 mm. ; B—3·0 mm. ; T—2·2 mm. *Glume colour* : *Rice* : White.
CO 13. Arupathamkodai.	110	Isolated from a short duration white rice variety *Arupathamkodai* or *Vellakodai* from Madurai, yielding 19 per cent over the local seed. It can be grown both in the first crop (June to September) and late *Navarai* (February to May) seasons. It is spreading in Amaravathi Valley in Coimbatore and in Chingleput districts. It has maintained an average increase of 20 per cent over the local unselected bulk. *Grain size* : L—8·1 mm. ; B—3·0 mm. ; T—2·0 mm. *Glume colour* : Straw with purple tip. *Rice* : White.
CO 17. Chinna Vadansamba.	Second of December ..	Isolated from *Vadansamba* grown in the Chingleput North Arcot and portions of Chittoor' Nellore and South Arcot districts under semi-dry conditions between July-December. This is a coarse type variety with stiff straw and bunched ears. Trials in Chingleput district were in favour of the strain by 10 to 25 per cent, increased yield over the local. Apart from yield in a tract—depending upon stored water supply in precarious tanks, its earliness combined with higher yields is much appreciated. Under semi-dry conditions of cultivation an acre yield of 2,500 lb. was recorded. *Grain size* : L—8·1 mm. ; B—2·8 mm. ; T—2·0 mm. *Glume colour* : Dull straw. *Rice* : White.

Paddy Breeding Station, Coimbatore—cont.

Number and name of strain. (1)	*Normal time harvest.* (2)	*Other particulars.* (3)
CO. 18. Vellaikar	125	Isolated from ***Vellaikar***, cultivated in Chingleput district, both in the south-west monsoon season (July to September) and '*Navarai*' season (December to January). The strain is a week earlier than the local and has recorded an average increase of 12·5 per cent over the local. It has yielded up to 2,700 lb. per acre, with an average of 2,260 lb. *Grain size*: L—8·1 mm.; B—2·9 mm.; T—2·0 mm. *Glume colour*: Straw. *Rice*: White.
CO. 19. Chingleput Sirumani.	Normal: third week of January. Thaladi: end of February.	This strain is isolated from *Sirumani* of Chingleput district. Its size is not the same as that of Sirumani varieties of Tanjore which are round in shape. This is similar to Molakolukulu of Nellore or Nellore samba of Tanjore. It yields 12 per cent over ADT 11 (Nellore samba) and PLR. 1 (Garudan samba). *Grain size*: L—7·7 mm.; B—2·8 mm.; T—2·0 mm. *Glume colour*: Dirty in furrows. *Rice*: White.
CO. 20. Tella sannavadlu.	July-November 130. January-May 120.	This strain was isolated from *Tella sannavadlu* of Chittoor district, where it is grown both in the '*Karthigam*' (July to November) and '*Vaisagam*' (January to May) seasons. The strain has recorded an average increase of 9 per cent over the unselected bulk. In the Chittoor district, where close planting and high manuring is practised, the average yield of the strain was 5,000 lb. per acre. *Grain size*: L—9·0 mm.; B—2·8 mm.; T—2·0 mm. *Glume colour*: Straw. *Rice*: White.
CO. 21. Arupatham samba.	100	This strain was isolated from '*Arupatham samba*' of Salem. It can be grown both in '*Kar*' (June to September) and '*Navarai*' (January to April) seasons. It has maintained an average increase of 16 per cent over the local unselected bulk with a mean yield of 2,400 lb. per acre. *Grain size*: L—8·3 mm.; B—2·7 mm.; T—2·0 mm. *Glume colour*: Straw. *Rice*: Red.
CO. 22. Manavari	115–110	This strain was isolated from *Manavari* of Salem district. It can be grown both in the '*Kar*' (June to September) and '*Navarai*' (January to April) seasons. It is particularly suited for cultivation during cold weather months of November-December when other short duration varieties do not thrive well. It has maintained an average increase of 20 per cent over the local unselected bulk. *Grain size*: L—8·0 mm.; B—3·0 mm.; T—2·0 mm. *Glume colour*: Straw. *Rice*: Red.
CO. 23. Rangoon samba ..	June-October (135 days). November-March (140 days).	The strain was isolated from *Rangoon samba*, a popular variety under Kalingarayan channel ayacut in Coimbatore district. The strain can be grown both in the first and second crop seasons. It has recorded an average increase of 14 per cent over ryots' bulk. Has yielded up to 3,500 lb. per acre. *Grain size*: L—9·9 mm.; B—2·8 mm.; T—2·0 mm. *Glume colour*: Straw with purple tip. *Rice*: White.

GEB. 24 Kichili samba ..	Fourth week of November.	Isolated from *Konamani*, probably a mutant. It yields best under early planted conditions and where the drainage is perfect and high manuring is practised. Its non-shedding habit, fine quality of table rice, comparatively higher proportion of rice to paddy by weight, and its tolerance to inadequate water-supply and somewhat saline conditions have commended themselves to ryots throughout the State. It is grown largely in the delta areas in the Circars and in Madurai as a first crop and as a second crop after '*Kar*'. It has given a maximum yield of 5,000 lb. per acre. It is the only variety grown in the Hospet taluk of Bellary. *Grain size* : L—7·8 mm. ; B—2·4 mm. ; T—1·8 mm. *Glume colour* : Straw. *Rice* : White.

Agricultural Research Station, Tirurkuppam (Chingleput District).

TKM. 1 Pisini (Culture 3532).	150	It is a pure line selection from the dry paddy variety called *Pisini* grown in the Chingleput North Arcot and Chittoor districts under purely rainfed and open conditions. It has given up to 20 per cent higher yield on the station. *Grain size* : L—8·0 mm. ; B—3·2 mm. ; T—2·0 mm. *Glume colour* : Dark furrows ripening brown. *Rice* : Red.
TKM. 2 Sembalai (Culture 3816).	150	It is a pure line selection from the dry paddy variety called *Sembalai*, grown in Chingleput and South Arcot under rainfed conditions. It has given up to 30 per cent higher yield on the station. *Grain size* : L—8·0 mm. ; B—2·9 mm. ; T—1·7 mm. *Glume colour* : Ripening gold. *Rice* : White (slightly goldish tinge).
TKM. 3 Swarnavari (Culture 2332).	90	This is a pure line selection from the variety *Swarnavari* grown during Swarnavari season in Chingleput, South Arcot over nearly one lakh of acres. It is a quick-growing robust variety and has given up to 15 per cent higher yield over the local on the station and 10 to 15 per cent in the district trials. Acre yields of 4,000 lb. were recorded on the station. *Grain size* : L—8·0 mm. ; B—2·9 mm. ; T—2·1 mm. *Glume colour* : Green ripening straw with purple tip. *Rice* : White (with abdominal white).
TKM. 4. Yerrasannavadlu (Culture 8907).	100	This is a pure line selection from the *Yerrasannavadlu* variety common in the Chittoor district during the Navarai (January-April) season. It is a light green type with bunched heads and fine grain. It has given up to 40 per cent higher yield over the local on the station. *Grain size* : L—8·8 mm. ; B—2·2 mm. ; T—1·7 mm. *Glume colour* : Green ripening gold. *Rice* : Dull white of fine quality.

CHAPTER 4.

MILLETS.

The different kinds of millets—Area and distribution—*Sorghum* varieties, trials, fundamental studies—physiology and genetics—wild and cultivated sorghums—Economic work—selection, hybridization—Agronomic and manuring experiments—Strains evolved—

Bajra.—Area, distribution, varietal interlocation trials—Selection—fundamental and cytological studies—Agronomic and manuring experiments—Strains evolved.

Ragi.—Area, distribution, varieties trials, fundamental and cytological studies—Agronomic experiments.

Minor Millets.—Arika, Variga, Samai and Kudiraivali—Area, distribution, cultivation trials and fundamental studies.

Introduction.—Millets form a group of annual cereal crops that are commonly grown in the warmer regions of the world, in areas that are too dry and poor for other crops like rice or wheat. In India, there are eight crops going under the collective name of millets namely, *Sorghum* (the Great Millet), *Bajra* (the Bulrush millet) or (Pearl Millet), *Ragi* (the Finger Millet), *Korra* or *Tenai* (Setaria or the Italian millet), *Varagu* (Kodo millet), *Samai* (the little millet), *Panivaragu* (the common millet) or (the Proso millet), and *Kudiraivali* (the barnyard millet). These eight millets are described in the following pages, with an account of the chief lines along which their improvement has been attempted in the State of Madras.

Millets occupy an area of nearly 60 million acres in the Indian Union, with an annual output of about 12 million tons of food-grains. They form the staple food of the rural folk in those areas where they are grown. In point of both area and importance, the millets rank next to rice in India, and precede wheat. They do not figure to any large extent in international trade, as the grain that is produced in India, is practically all consumed within the country itself.

In Madras, the millets cover an area of 12·8 million acres, with an annual production of three million tons of grain. Millets serve both as food for men and as fodder for cattle and are in fact superior to rice in both these respects. Millet improvement was taken up in this State in 1923, when a separate Millets Breeding Station (Plate 14) was started at Coimbatore, under a whole-time research officer who was designated the Millet Specialist. A large volume of fundamental genetic information was gathered in the early years, as a preliminary to the evolution of improved, high-yielding strains in each of the millet crops. In the course of this work it became apparent that millets were highly localised in their

Plate 14 - The Millets Breeding Station, Coimbatore.

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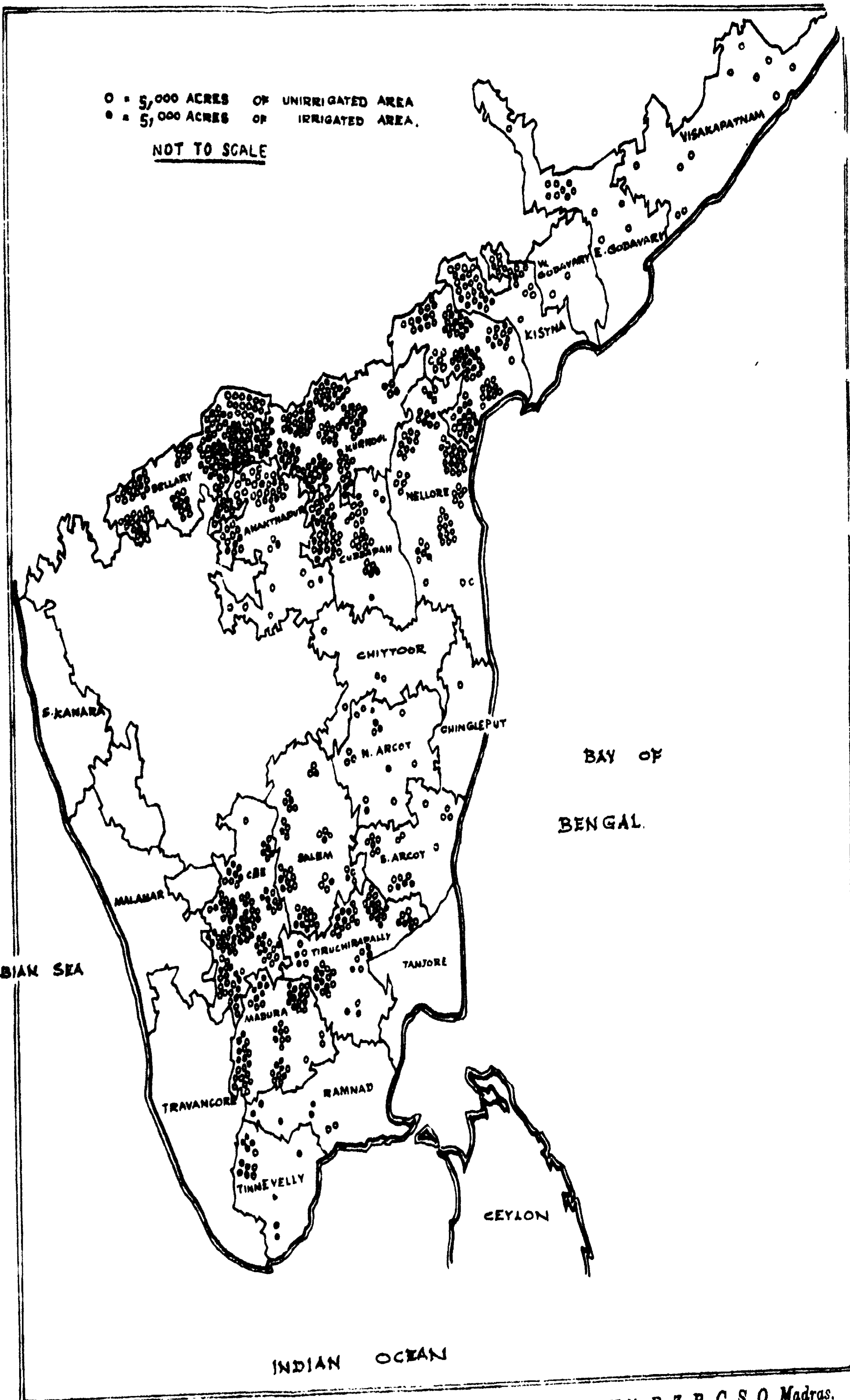
DISTRIBUTION OF SORGHUM CROP IN MADRAS STATE

1948-49



Helio P. Z. P., C. S. O., Madras.

Reg. No. 55 '52-750

habits, so that it was necessary to spread out the work in the different millet-growing areas of the State, if useful results were to be achieved by way of improved varieties suited for each of the different millet areas.

Sorghum (*Sorghum* sp.)—*Production and importance—The Great Millet* (Telugu—*Jonna*; Tamil—*Cholam*; Kannada—*Jola*; Malayalam—*Cholam*; Hindustani—*Jowar*).—Sorghum is the most important among the millets and occupies an area of 36 million acres in India, with an annual outturn of 5·7 million tons of grain. It is grown mainly as a rainfed crop, in Hyderabad, Bombay, Madras and the Central Indian region. Madras stands third, with an area of 4·8 million acres under this crop, forming about 12 per cent of the total cultivated area. The area under this crop in different districts is given below (Plate 15) :—

District.	Total area.	Irrigated.	Unirrigated.
	ACS.	ACS.	ACS.
Bellary	692,660	3,660	689,000
Kurnool	576,250	3,250	573,000
Coimbatore	546,000	129,000	417,000
Guntur	401,500	2,500	399,000
Nellore	382,560	8,560	374,000
Ananatapur	321,000	23,000	298,000
Madurai	277,000	79,000	198,000
Tiruchirapalli	271,800	37,800	234,000
Salem	261,400	37,400	224,000
Krishna	217,150	150	217,000
East Godavari	94,510	10	94,500
Tirunelveli	91,500	67,300	24,200
South Arcot	77,680	1,280	76,400
North Arcot	75,400	17,900	57,500
Visakhapatnam	72,050	50	72,000
West Godavari	70,140	40	70,100
Ramanathapuram	62,100	23,000	39,100
Chittoor	42,900	11,300	31,600
Chingleput	5,040	210	4,830
Malabar	980	..	980
The Nilgiris	90	..	90
Total ..	4,828,110	455,810	4,372,300

It will be seen from the above figures that the chief sorghum-growing districts are Bellary, Kurnool, Coimbatore, Guntur, Nellore, Anantapur, Madurai, Tiruchirappalli, Salem and Krishna. The average annual production of sorghum grain in Madras amounts to 1,150,000 tons. Its importance as a food crop lies in its being the heaviest yielder of both grain and straw among all the rainfed cereal crops. The grain serves as the staple food of the poorer classes while the straw is a very good fodder for cattle.

Climate, soil, irrigation and their influence on cultural practices.—Sorghum is an important crop wherever the rainfall is low and less than 35 inches per year.

Seasons.—There are two main seasons for sowing sorghum as a rainfed crop, the early season in June–July and the late in October–November. In Nellore and Guntur districts the early (*punasa*) crop is sown in June, the main or midseason crop (*pedda*)

from July to September and the late (*pyru*) crop in November. Under irrigation, sorghum may be grown at any time of the year, though it is usual to sow it either in December or in April-May. The yield under irrigation is about three to four times the yield that can be obtained from rainfed crops. The practice of growing sorghum under irrigation is more common in the southern districts particularly in Salem, Coimbatore, Madurai, Ramanathapuram and Tirunelveli, than in the northern districts of the State.

Soils.—Sorghum can be grown on a wide variety of soils, light or heavy, black or red, though sandy soils have to be heavily manured. It thrives best on soils well supplied with lime, as in the heavy " black cotton " soils of the Ceded Districts. The crop does not stand any water-logging. The season for sowing sorghum is generally so chosen that the rainfall during its growing period does not exceed 10 to 15 inches.

Varietal collections, introduction and trials.—A very large number of types and varieties from all over the Madras State as well as other parts of India and other countries was first collected when the Millets Breeding Station was started in 1923 and these were studied in respect of their varied characters, their range of variability and suitability as material for the evolution of high-yielding strains. Extensive genetic studies were also carried out on the mode of inheritence of the various characters, both morphological and economic and a brief account of the knowledge gained in these studies is given below, followed by description of the improved sorghum strains evolved in the Millet Breeding Station at Coimbatore and at the different regional sub-stations in other districts of the State.

Fundamental studies.—In sorghum, the chief types that are cultivated in Madras are the following :—

Sorghum durra.—Most of the dry land types, with semi-compact earheads and yellow grain come under this group, which is grown chiefly in the States of Madras, Bombay and Madhya Pradesh, and in certain parts of the Punjab and Uttar Pradesh.

Sorghum cernuum is grown in Bombay, Deccan, Madras and the Madhya Pradesh. Most of the varieties in this group have bold white pearly grains.

Sorghum subglabrescens.—Most of the irrigated varieties in Madras belong to this group, which is grown also in Bombay and in Madhya Pradesh.

S. Roxburghii is a loose-panicled species, grown in the poorer and lighter soils of Madras, Madhya Pradesh, Bihar and Orissa. The species is suited to areas of higher rainfall than the other species can tolerate.

S. Lochna is grown mostly in the southern districts of Madras and parts of Bombay. It is known under the name of *Irungu* cholam in Madras, and is characterised by the grain being enclosed almost completely by the glumes. It is cultivated mainly as a fodder crop using a very high seed rate of 60 to 80 lb. per acre to secure a thin-stalked fine fodder.

Root system.—A characteristic feature in all sorghum plants is the occurrence of stilt roots at the nodes immediately above ground level. These help in supporting the plant when it gets rather top heavy as the earhead ripens. It is found that even the higher nodes are capable of developing these stilt roots when the leaf sheaths are stripped off and the nodes exposed to favourable conditions of humidity and temperature.

Height and duration.—There is a very wide range in both height and duration in sorghum varieties, from 75 to 170 days in duration and 24 inches to 180 inches in height. In general, the taller varieties have the longer duration though exceptions do occur, as in the *Tella jonna* of Bellary district, where the plants are comparatively short, even though the duration is 130 days. Three broad groups can be distinguished, the early (75 to 100 days), medium 100 to 130 days and late (130 to 170 days). The shortest variety is a two-foot *Milo* from New Mexico and the tallest is *Sorghum elagans* from Tanganyika with a height of nearly 180 inches. It was observed that with increasing height and duration, the number of internodes per plant also increases. In the short duration group, there is a progressive increase in internodal lengths from the bottom upwards, the last internode or peduncle being the longest. In the medium duration, the internodal lengths show a unimodal disposition, the lengths first increasing, then decreasing and then again increasing to the peduncle. The late types show a bi-model disposition, with a double rise and fall of internodal lengths, with a final rise in the peduncle. The lengths of the leaf sheaths also follow the variations in internodal lengths, though in a less marked manner.

Panicle.—Amongst the cereal crops, sorghum is remarkable for its wealth of panicle shapes and sizes, varying from the very compact, round and cricket-ball-like panicle of Tella Jonna (*S. cernuum*) to the very loose and streaming type of panicle in the Broom corn (*S. dochna*). From the studies carried out in the Millets Breeding Station at Coimbatore on the structure of these panicle shapes, it has been found that they arise from the various combinations of lengths of rachis and primary branches, the degree of ramification of branching, the angle which the whorls of branches make with the main 'rachis' and the density of clustering of the fertile spikelets on these branches. The final grain yield in different varieties is conditioned by the weight and size of the individual grains and the factors that determine the number of fertile spikelets. Hence the shape and size of the panicle have a close relation to the ultimate yields of different sorghum varieties.

Anthers and stigmas.—Anthers in sorghum vary in size though not in shape and the common cultivated varieties possess about the largest-sized anthers. The pollen grains too vary in size and the variations are roughly parallel to anther size differences. The colour of the fresh anthers is either yellow, light yellow or very light yellow. No white anthers have been observed so far. The

stigmas and stigmatic branches are also yellow in colour, the variations in the depth of yellow are usually associated with the colour that the grains develop later on; the deeper-coloured grains, like yellow, red or brown have deep yellow stigmas, while the white-grained and very light yellow-grained types have very light yellow or white stigmas. The anther sacs on drying develop various shades of three broad groups of colours, brown, red and sienna which show a close parallelism with the grain colour that is developed later.

Other morphological peculiarities—Midrib-forking.—The sorghum leaf has an entire margin, with a single, well-marked midrib, but occasionally this midrib forks into two over the entire length of the leaf. In certain species, non-auriculate and eligulate types are also met with. In species where economic varieties are found, there is a *pulvinus* or cushiony structure at the base of the spikelet-bearing branchlets, at the junction with the main axis, which results in pushing the grain-bearing portion well away from the central axis, whereas in the eligulate and non-auriculate types, there is an absence of the pulvinus and a shortening of the spikelet-free area in the panicle branches and branchlets, leading to an overcrowding of spikelets on the earhead with a consequent risk of sterility.

Spikelets.—Two kinds of spikelets are found in a sorghum panicle, the sessile and the pedicelled. The sessile spikelets are fertile and persistent, while the pedicelled ones are generally sterile and sometimes deciduous. The deciduous, sessile spikelets occur only in the wild sorghums. In crosses between wild and cultivated sorghums various types were met with, some being closely similar to cultivated sorghums until flowering was over, but at the milk-stage, the sessile spikelets start shedding. The occurrence of fertile, pedicelled spikelets also has been recorded; these grains being usually smaller than those from sessile spikelets.

Dummy pollen.—Another abnormality is the occasional occurrence of "dummy pollen", i.e., empty pollen grains that are lighter in tint than normal pollen, and which do not shrivel up on drying as normal pollen grains do. Various abnormalities are also met with in the awns. As a rule only the fourth and the innermost glume, out of the four glumes in a sorghum spikelet, that has a palea encloses the floral parts. The awn is developed on this fourth glume or lemma, but in certain types of sorghum where double grains were found, the palea of the fourth glume also was found to develop awns.

Cleistogamy.—In certain forms from Africa and in an Indian type belonging to *sorghum papyrascens*, it was noted that the panicles never showed any evidence of flowering, like emergence of anthers or stigmas. Here the lower floral glume was wide and clasped the upper floral glume (lemma) tightly. The lodicules also were degenerate, scaly and functionless, with the result that the glumes were unable to open out. The anthers

were small with short filaments, and were able to pollinate the stigmas due to their being stuck up against the stigmas. The seed-setting was, however, much poorer than normal, so that this feature is not a desirable one.

Double seeds.—In certain extra fertile types, the spikelets bear two pairs of stigmas instead of one and at maturity contain two grains within the same pair of glumes. This doubling naturally reduces the weight of individual grains and is thus not an economic character. Multiple-seededness also has been observed and recorded in sorghum where the third glume also becomes fertile and produces a grain.

Cracked grains.—The sorghum grain is rather unique among all the cereals in being completely exposed, without being enclosed in the glumes, and hence the importance of a sound and unbroken pericarp is obvious. A few African types of sorghum were, however, observed at the Millets Breeding Station to have cracked grains. These cracks are formed at the dough stage as a cleft, exposing the white starch inside the grain and have been noted so far only on chalky-grains with a soft endosperm.

Vivipary.—The phenomenon of the seed germinating on the plant itself is not common in the cereals, but one instance has been noted in sorghum, where the grain failed to go into the dormant stage but germinated on the earhead itself, resulting in vivipary.

Bulbils.—In the second generation of certain crosses made between single-seeded and double-seeded varieties of sorghum, small, leafy greenish structures were noted in the spikelets during the pre-ripening stages. These, on closer observation, were found to be bulbils, resulting from the conversion of the grains and glumes into four or five leafy structures, progressively increasing in length from the bottom to the top. A mutant was found in which all the spikelets proliferated into tiny sorghum plants, and when transplanted, were able to strike root and grow but they never set any seed.

Histology—Pericarp of grain.—The histology and organography of the pericarp has been studied on the grains of numerous wild and cultivated races of sorghum at the Millets Breeding Station. In the sorghum grain the inner epidermis of the pericarp gives rise to the tube cells; and the integument is formed not from the nucellus but from the inner integument. The nucellus in sorghum is completely absorbed. The wild sorghums are characterised by a very thin pericarp, consisting of only the epidermis and tube cells and sometimes a very small tissue of the mesocarp. An integument is always present in wild sorghums which is brown-coloured. The cultivated sorghums also have similar layers, but they are more in number than in wild sorghums. The integument is found in cultivated types, only in some but not in others. When present, this integument is always brown in colour, and the tube cells too are likewise brown. The

mesocarp is coloured only in very rare cases. The colour of the pericarp is found in the epidermis, hypodermis and the tube cells. Examination of the hybrids and parents of crosses revealed that while neither of the parents showed any integument their hybrid had an integument indicating an origin through complementary genes. A monogenic difference for integument colour has also been recorded from other crosses and it was observed that an integument was invariably present when the grain was brown-coloured and absent when the grain was not brown.

Physiology—Anthesis and Pollination.—The general order in the flowering of the panicle in sorghum is from the top to bottom with about eight days for completion of flowering. The spikelets generally start opening from 12 midnight, till 2 a.m. though sometimes this anthesis may continue up to 8 or 10 a.m. As an exception to the general rule, one species, *sorghum margaretiferum*, has been observed to be a day-flowering type. As mentioned earlier, the anthers in sorghum vary a good deal in length and breadth, with a positive correlation between the sizes of anther and grain. Sorghum pollen is highly sensitive to the medium in which it is grown. Sucrose with shred agar is the best medium for artificial germination of sorghum pollen, among which the day-flowering varieties having a higher percentage of germination than night flowering varieties. The germination in an artificial medium was also found to be better on cloudy days, and the best germination material was pollen gathered between 7 a.m. and 8 a.m. The temperature should be below 40° C for satisfactory germination and darkness acts as an inhibiting factor. Pollen is capable of fertilising the stigma up to the third day from the opening of the spikelet opening though less effectively than when it is fresh. The stigmas retain their receptivity up to 48 hours after emergence, this being inhibited by darkness and impaired by rise of temperature and humidity.

Genetics—Grades of chlorophyll content.—Three distinct groups of greenness can be distinguished in different varieties of sorghum, a dark-green, green and light-green. An estimation of chlorophil content in these groups showed that the dark-green and green contained 22 and 17 per cent more chlorophyll respectively than the light-green type. There was more of chlorophyll-a, in the light-green types whereas in the other two types there was more of chlorophyll-b. Most of the African sorghums are dark-green, the Indian varieties green, and the Chinese varieties light-green. Crosses were made to study the mode of inheritance of this character and it was found that dark-green was a monogenic dominant to green which in turn was dominant to light-green, and that all three characters segregated in the ratio of 9 : 6 : 1, indicating the operation of two supplementary factors for colour development. Either of the two factors can deepen light-green into green but both of them should operate to produce a dark-green colour. In the seedling colours too there is a variation; the African varieties having a bluish green tint in contrast to the pure green

tint in the seedlings of Indian varieties. This difference also behaves as a monogenic dominant giving rise to the bluish-green tint when present and ordinary green when absent.

Plant pigment.—Sorghum plants may be completely green or purple in certain plant parts. The pigmented condition is ordinarily seen best in the adult plant when the tissues begin to dry up, though in some African varieties the pigment is manifested even when the seedlings are a week old. The gene responsible for this character is dominant to the one by which the seedlings remain green.

Midrib colour.—The midrib in sorghum is usually white or a dull green, and is correlated with the nature of the culms or "stalks". When the stalk is juicy, the midrib is dull green, and white if the stalk is pithy. The pithystalky character is dominant to the juicy and this character is important from the point of view of evolving good fodder types of sorghum with juicy stalks. The occurrence of a brownish-purple midrib, which behaves as a monogenic recessive to the non-brown midrib, has also been recorded. In some types, yellow midribs have also been noted which is a monogenic dominant to the ordinary green midrib and is, in addition, linked with the factor for reddish-purple on the leaf-sheath.

Colour of sheath and glume.—Sorghum leaf-sheaths are either purple or brown. The purple behaves as a monogenic dominant to the brown. In the purple itself there are two sub-groups, reddish purple and blackish purple, the former being dominant to the latter.

Colour of node.—There is a band of soft, cushiony tissue above the nodes on sorghum plants, which in some varieties is coloured purple. This purple node is dominant to the green. The pigment may be of two kinds, one being associated with the factor for brown grains and the other being closely linked with a sienna-coloured anther.

Ligule and auricle.—In sorghum, as in all grasses, there is a well-marked zone at the junction of the leaf-sheath and leaf-blade, consisting of a narrow ligule as a prolongation of the distal inner margin of the leaf-sheath and a lighter-coloured, triangular, membranous tissue which is known as the auricle. The occurrence of an eligulate and non-auriculate condition has been observed and recorded, which behaves as a recessive to the normal ligulate and auriculate condition. As mentioned earlier, the non-auriculate condition is associated with the absence of a pulvinus in the panicle, and a shortening of the spikelet-free area in the panicle branches and branchlets. This leads to an overcrowding of spikelets on the panicle and a consequent risk of sterility.

Hairy leaf tips.—Hairiness is practically absent in sorghum plants on the stalks, leaves and leaf-sheaths, but is present as a primitive character in wild sorghums, and as a vestigial character in some of the cultivated varieties which behaves as a monogenic

dominant to the hairless character. In some cases the hairs occur on either side of the midrib groove on the lower half of the leaf-blades particularly on the flag.

Tip sterility.—Earheads with sterile tips are uneconomic. The gene responsible for this character of tip sterility is monogenic recessive to the one that produces normal, fully fertile earheads.

Spikelets.—In most of the cultivated sorghums, the spikelets are fully persistent and it is only in wild sorghums that the uneconomic character of deciduous spikelets is met with. The gene responsible for shedding is a monogenic recessive to the persistent one. Another spikelet character that was studied genetically was purple pigmentation of the hairs, which was a monogenic dominant to the normal hyaline type of hairs.

Awns.—In the sorghum spikelet the fourth glume (lemma) bears the awn, and when present, the awn length keeps pace with the length of the spikelet. Small, ovate glumes with short awns have proved a monogenic dominant to large, elliptic glumes with long awns.

Purple colour on floral parts.—A purple-pigment is developed on the glumes about three weeks after the emergence of the panicle from the boot, when the grains are in the dough stage. Till then the glumes are green. In some of the African sorghums, a new character has been noted, the assumption of a purple colour by the glumes, just after emergence from the boot. This character is a simple dominant to the normal ripening-purple character. In the same manner, purple anthers have also been noted in some of the African varieties as a rare variant from the usual yellow shades and behaving as a simple dominant to yellow anthers.

The stigmas are generally feathery in sorghum and the styles smooth, but non-feathery stigmas have been noted in certain varieties from Central and East Africa. In such varieties, the awn, when present, has barbs only on the lower half of the subule, indicating the homologous nature of both awn and stigma. A fully-feathered stigma is dominant to a basal-feathered stigma. Another variation is a stigma with sparse feathers which is also recessive to the normal fully-feathered stigma. Both these characters are uneconomic and hence not desirable and it is fortunate they are both recessive and hence remain as rare characters.

A purple pigment has been observed in the sub-epidermal layer of the pericarp of the ovary at the time of flowering in a few species of sorghums of African origin. This character behaves as a monogenic dominant to the usual hyaline condition, linked with the colour of the leaf-sheath and glume grain colour and juiciness of stem.

Grains.—Unlike other cereal grains the developing grain in sorghum lacks protection both in the early and late stages of development. Unlike ragi, where too, the grain is naked, the sorghum grain has not got the protection of a papery pericarp, nor has it, like Bajra, the protection of a mass of dry anthers in

the early stages. Sorghum grains can be grouped into two main classes, the pearly and the chalky. In the absence of any definite colour like red, yellow or brown, the grain is pearly in appearance, shiny and translucent. In the chalky grain this lustre is lacking and it is opaque. Chalky grains are common in varieties of *Sorghum, Roxburghii*, locally known as *Talaivirichan cholam*. These differ from pearly grains in having a mesocarp layer thrice as thick as that in pearly grains. This layer is full of starch grains and give the chalky look to the grain as a whole. Soaking experiments showed that in five hours chalky grains absorbed 24 per cent and pearly grains 18 per cent of their dry weight of moisture. Chalky grains are relatively more susceptible to weevil attack, while pearly grains are better for popping. The starchy condition of the mesocarp, showing itself as a chalkiness of grains, behaves in inheritance as a monogenic recessive to the non-starchy mesocarp, giving a pearly grain.

Sorghum shows a wide variety of grain colours, ranging from reddish-brown, deep red, red, light red, deep yellow, yellow, light yellow and white with and without red tint. In addition, some grains may have a brown wash, while others do not show any brown wash. These different colours fall into two groups, tannic and anthocyanic. In the anthocyanic group, yellow is the basic colour. With the addition of a red factor, the grains become red. Another factor determines the location of colour manifestation whether it is all over the pericarp or confined to a portion of it only. A third factor determines the intensity of colour manifestation. Thus red, without this intensification factor, gives only a light red grain. Monogenic and digenic interactions of these factors have been studied over a number of years in a series of crosses at the Millet Breeding Station, Coimbatore.

In the brown-grained tannic group, two factors acting concurrently are responsible for the production of a fully-brown grain. Each of them by itself is capable of imparting only a light-brown wash to the grain and can be detected only by the brownish colour of the dry anther. The interaction of all these factors, the tannic browns and the anthocyanic reds and yellows along with their colourless allelomorphs, results in the wealth of blended colours that are found in sorghum grains.

Dimpled grain.—In the sorghum collections at the Millet Breeding Station, there is a variety from Bellary district, known as *Sakkala Sakkara Guliga jonna* (Sugar-pill sorghum), where the grains are " dimpled " with a small depression on the distal end of the grain. When the grains are cut longitudinally, a small hollow is visible immediately below the dimple. Although the types having these dimpled grains are not very vigorous, they are esteemed by cultivators for their soft and tasty grains especially in the dough stage. Dimpling can occur in grains with floury as well as corneous endosperm, and has been noted in white, yellow, red and brown grains, and also in pearly or chalky grains. Dimpled

grains contain nearly three times the quantity of reducing sugars found in non-dimpled grains. The starch grains in the dimpled types are also smaller than normal, due presumably to an arrested development. As the grain ripens and loses moisture, the imperfect development of starch grains leads to an unfilled cavity at the distal end which appears as a dimple externally. The dimpled character is a monogenic recessive to non-dimpling.

Blotches on grains.—In some varieties of sorghum, the stylar scar is surrounded by a small purple spot, which behaves as a simple dominant to the grain without a purple spot. This spot is reddish purple or blackish purple according to the leaf-sheath colour. As a variant of this purple spot, blotches of purple also occur on the grains in some varieties of African origin.

Linkage relations.—In sorghum, there is a linkage between the genetic factors determining the colour of leaf sheath and glume and the factors for brown colour in the dry anther and grain. Some varieties of sorghum possess a coloured reddish-brown integument layer just outside the aleurone layer. When varieties with a blackish purple leaf sheath and coloured integument layer are crossed with varieties having a reddish-purple leaf sheath and no colour in the integument layer, it is found in the second generation that the double recessive group, blackish purple, colourless integument is absent, indicating that the factors for blackish purple leaf sheath and coloured integument layer are completely linked. Another instance of linkage is between the pearly-chalky grain colours and loose-compact panicle shapes. Whereas the loose panicle gave both pearly and chalky grains, only pearly grains were found in compact panicles. The double recessive chalky-compact combination was absent.

Waxy bloom.—Control of transpiration is effected in plants by various adaptations, including the secretion of wax. In sorghums the epidermis is coated with a waxy " bloom ", which is much thicker on tropical types than in sub-tropical types. Under normal conditions, irrigated types produce less of waxy secretion than rainfed ones. The plants have also the valuable feature of re-generating the waxy secretion as long as it is required. Genetically, the " heavy bloom " character is dominant to " sparse-bloom ". One variety from Tanganyika was found to be completely devoid of any bloom. When this was crossed with sparse-bloomed and heavy bloomed types, it was revealed that another factor was also responsible for the production of bloom in sorghum; when this second factor also was absent, a completely bloomless condition resulted.

Cleistogamy.—The failure of spikelet opening results from a factor which is responsible for the rolling in of the edges of glumes, as a result of which the glumes fail to open, and fertilization takes place inside the spikelet. This gene can manifest its presence only on a papery glume.

Chlorophyll deficiencies.—Numerous types of chlorophyll deficiencies occur in sorghum, the commonest being a complete absence, resulting in seedlings that are white in colour. Such a complete albinism is lethal and white seedlings invariably die off in four or five days.

Under the microscope it is seen that albino leaves are devoid of not only chlorophyll but of the plastids as well. A second type of deficiency is where the seedlings are pale-green and have a chlorophyll content of about 40 per cent of the normal. These die off by the twelfth day. A single gene differentiates this "lethal pale-green" from the normal greens. A third type of deficiency is represented by the "virescent whites", where the seedlings appear to be very light green, giving the leaves a yellowish look. These too are lethal and single gene differentiates between normal greens and "virescent whites". The chlorophyll content in these is only 5 per cent of the normal. A fourth type of deficiency exists, where the chlorophyll is 51 per cent of the normal and the seedlings manage to live for about six weeks and reach a height of six or seven inches, after which they wither and die. A fifth type of deficiency is the surviving type; the plants in this group are able to live, but the growth is very poor. Yellow or "xantha" seedlings have also been noted as yet another type of deficiency. These too are lethal and behave as a monogenic recessive to green seedlings. A seventh type is the "patchy albino", also recessive to normal green seedlings. They can be kept alive for about two months, with great care, but after that period, death is inevitable.

Mutations.—The occurrence of new types of plants as a result of genic changes is now well-known to plant breeders to whom they are sometimes helpful from an economic standpoint. In sorghum, a mutation has been recorded where the leaf sheath internode, midrib, panicle and glumes were all brown. This brown was not anthocyanic, and the mutant behaved as a monogenic recessive to the normal plant with green internodes and white midribs. Another mutant was a dull-midribed plant observed in a pithy-stalked type of "*Muthialu jonna*" from Hindupur (Anantapur district). A third instance was a plant with long awn and dull midrib in an awnless pithy-stalked type.

Tiny sorghum.—A tiny plant averaging 18 cms. in height as against the normal height of 150 cms. in the parent family has been observed and studied in sorghum. Heterozygous earheads from crosses, when germinated *in situ* showed two types of seedlings, normal and tiny. This dwarfing is brought about by the loss of a single gene and behaves as a simple recessive to the normal type. In such "tiny" plants, the number of internodes is the same as in normal plants, though very much reduced in length. The panicles also are greatly reduced in size, the anthers are devoid of pollen grains except in stray cases. The stigmas are however receptive and hence the perpetuation of this

rare type is possible only through segregating heterozygotes obtained after crossing with a normal plant.

Correlations in sorghum.—Height and duration are important economic characters in sorghum as in other crops. Usually early types are short, while late types are tall. The latter group has 17 to 18 internodes on the stalk, with a bimodal distribution of internodal length while, in the former the internodes are fewer (eight to nine) with a unimodal distribution of internodal length. Earheads on tall plants are heavier than those on short ones. The "short-early" is a monogenic dominant to the tall-late plants.

From a detailed study of the different types of correlations that exist in sorghum between the weight of panicle in the mature stage (earhead) their length and thickness and the diameter of peduncle, it is now possible to predict the total grain yield of a plant, when the diameter of the peduncle, the length and thickness of earhead and the weight of 100 grains are known.

Cytogenetic studies.—All cultivated grain sorghums were found to have $2n = 20$ chromosomes. In the wild sorghums, the para-sorghums were found to have $2n = 10$ chromosomes while in *Sorghum halepense*, the chromosome number was $2n = 40$. One wild species, *Sorghum stapfii* not reported before, was found to have $2n = 20$. Thus the collection available at the Millet Breeding Station included simple diploids with $2n=10$ chromosomes, tetraploids with $2n = 20$, as well as octoploids with $2n = 40$ chromosomes. More recently, tetraploid forms with $2n = 20$ chromosomes were observed in *Sorghum halepense* also. These tetroploid plants were larger than the octoploids.

In addition to these cytogenetic studies on sorghum a histological study has also been made of various cultivated and wild types of sorghum to understand the basis of the colour, size and structural variations found in this crop plant. In colour two types exist, viz., the anthocyanic and the non-anthocyanic, the former being confined to the epidermal layers of the pericarp of the grain, whereas the latter was present in the integuments. In the sorghum grain (botanically a caryopsis) the pericarp is persistent, and the outer integument as well as *nucellus* are absorbed when the grain develops. In brown grains the inner integument is coloured, due to tannin deposits. This colouration was reported by American workers to be present in the nucellus, but the work done at Coimbatore places the colouration in the inner integument. The brown tannin deposit renders the grain somewhat bitter so that it is not a desirable character.

Wild sorghums and their relation to cultivated species.—The wild sorghums are believed to be ancestors of cultivated sorghums. The latter, under the fostering care of farmers, underwent a lot of changes in which undesirable traits were eliminated and desirable economic characters retained. But the wild ones

continue to grow in their natural habitants, unprotected and uncard for. Some of them in recent times have acquired a certain amount of economic importance as fodder grasses.

The genus sorghum is classified into broad sects *Eu-sorghum* or true sorghums and (2) *Para-sorghums*. The distinguishing characteristics of the Para sorghums are the conspicuously bearded nodes and very prominent awns (length being up to 40 m.m.). They have only half the number of chromosomes found in the cultivated species. The true sorghums are further classified into subsects—*Arundinacea* and *Halepensia*. The latter consists of only one known species—*Sorghum halepense* which is popularly known as " Johnson grass ". It is a perennial with prominent rhizomes and has double the number of the chromosomes found in the cultivated forms. The subsect *Arundinacea* has been divided into two series—*Spontanea* and *Sativa*. The former contains the important species of wild sorghums, from which the cultivated ones are presumed to have evolved. They have ten pairs of chromosomes as in the cultivated forms, but different from them in many morphological characters. All the cultivated species of sorghums belong to the series *Sativa*, and the innumerable varieties and forms met with in these species go to make the wealth of variations existing in this Great Millet.

(1) *Para sorghums*.—As recorded above, the para sorghums constitute a separate group by themselves and are believed to have contributed little to the evolution of the cultivated ones. The important known species belonging to this group are:— *S. purpureosericeum*, *S. versicolor*, *S. dimidiatum*, and *S. nitidum*, A study has been made of the affinities, inter-relationships and differences of these four species. *S. purpureosericeum* and *S. dimidiatum* are very closely related to each other. The slightly reduced, half-coriceous glume of the latter is the only difference noticed and is brought about by a single gene. *S. versicolor* and *S. nitidum* show even greater affinity to each other. The sorghums of this group do not have much fodder value in South India, as they are unable to stand cuttings or any slight disturbance to their root system.

(2) *Other wild sorghums*.—The wild sorghums belonging to the Arundinacea group have also been studied. The Sudan grass, *S. Sudanense* belongs to this subsect. In one pure line of Sudan grass from Russia the tips of all leaves from the fourth leaf upwards was found to dry up. Concurrently with this desiccation there was a drying up of the tip of the panicle also. This character was recessive to the non-desiccated condition. The peduncle in sorghum is usually straight. In some it is slightly wavy. This waviness predisposes to goosenecking. In Sudan grass the wavy peduncle is recessive to the straight one. The rare occurrence of eligulate and non-auriculate condition has been recorded in the cultivated sorghums. In an eligulate type of Sudan grass, every panicle was found to have side-shoots with two or three leaves and occasionally

with tiny terminal panicles from the axils of the panicle branches. This type was crossed with the normal ligulate type. The segregations showed a close linkage between the factors causing eligulateness and axillary shoots in panicles.

Sorghum halepense.—This is the earliest known wild sorghum. It belongs to section *Eu-sorghum* and sub-section Halepensia (Snowden). The presence of rhizomes is the distinctive feature of this group. A study has been made of the samples both Indian and foreign. Purple colour in the stigma is a monogenic dominant over the non-pigmented condition (yellow). An interesting experience in anthesis (probably mutational in origin) has been noted in a variety of *S. halepense* received from Palestine. Here the filaments fail to elongate. This results in the anthers being stuck up inside the flower, resulting in poor pollen content and only stray dehiscence. The stigma being normal and receptive, there is natural crossing. The reduced filaments are a simple monogenic recessive to the normal filaments. The compact panicle in this species was found to behave as a monogenic recessive to the loose panicle. Stray cases of extra fertility of spikelets and ovaries with triple stigma have also been found to occur in *Sorghum halepense.*

Economic Work—Evolution of strains—By selection.—The work of the Plant Breeder is one of continuous effort to find out varieties that are superior to what exist already. This is achieved by the introduction of new varieties from other tracts, by selection of improved types and by hybridization, followed by further selection and isolation of superior types that combine desirable features from two or more cultures. Side by side with the genetic and other fundamental aspects that were studied in this crop, experiments were also carried out from the very inception of the Millets Breeding Station at Coimbatore, to evolve superior strains that would give better yields than the varieties now grown in different tracts and also to evolve strains that would suit tracts where existing strains were not acceptable. A number of high yielding strains have been evolved already at Coimbatore and other stations in the State. [Plates 16 (*a*) to (*d*).] Strains suited for both irrigated and rainfed conditions have been evolved. These have become popular and are capable of yielding from 10 to 15 per cent above the local varieties. A summary of the strains that have been evolved at the various Research Stations is given below :—

List of improved strains evolved in sorghum.

Strain number.	*Sowing season.*	*Remarks.*
	Agricultural Research Station, Anakapalle.	
AKP. 1 ..	June-October to November-February.	Pedda panta.
AKP. 2 ..	Do.	Do.
AKP. 3 ..	Do.	Yields more fodder.

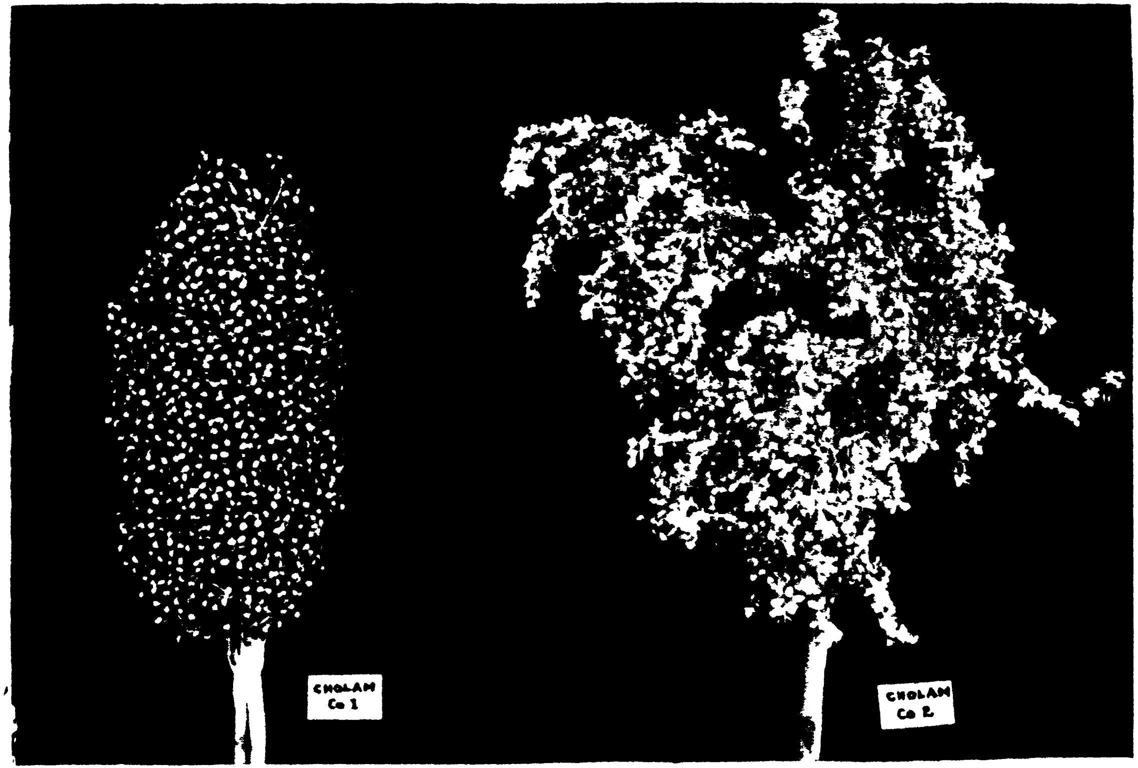


Plate 16 (*a*).—*Improved Sorghum strains.*

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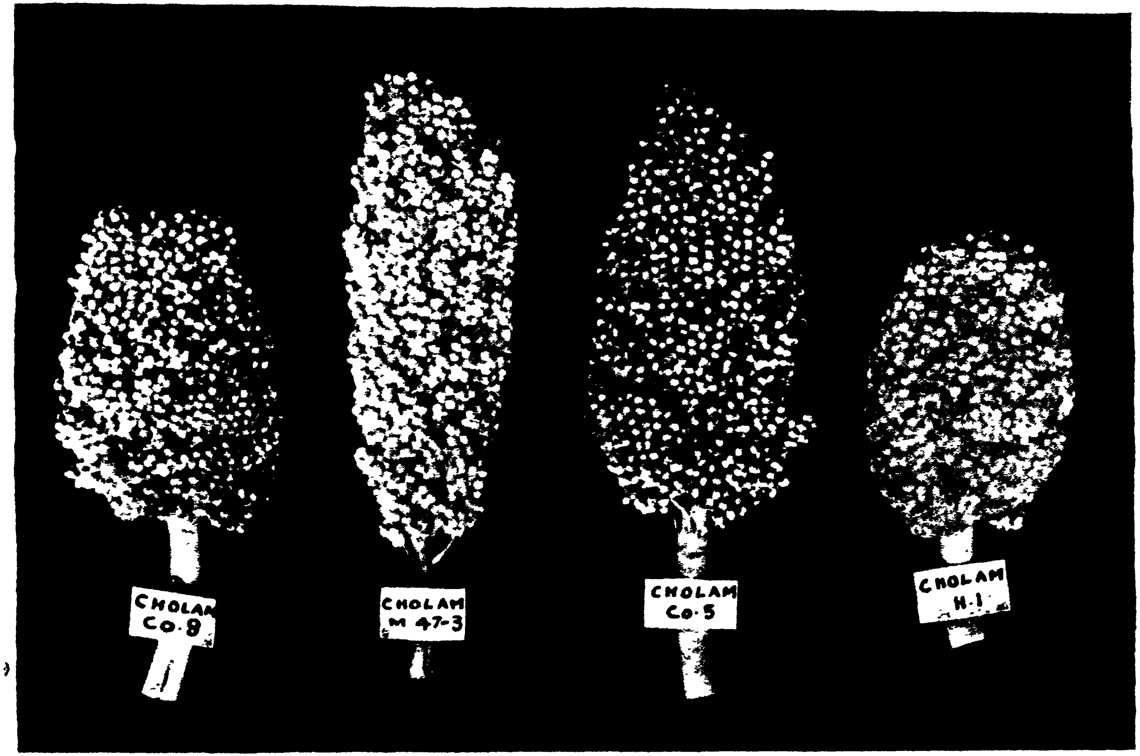

Plate 16 (*b*).—*Improved Sorghum strains.*

Plate 16 (c). - Improved strains of millets.

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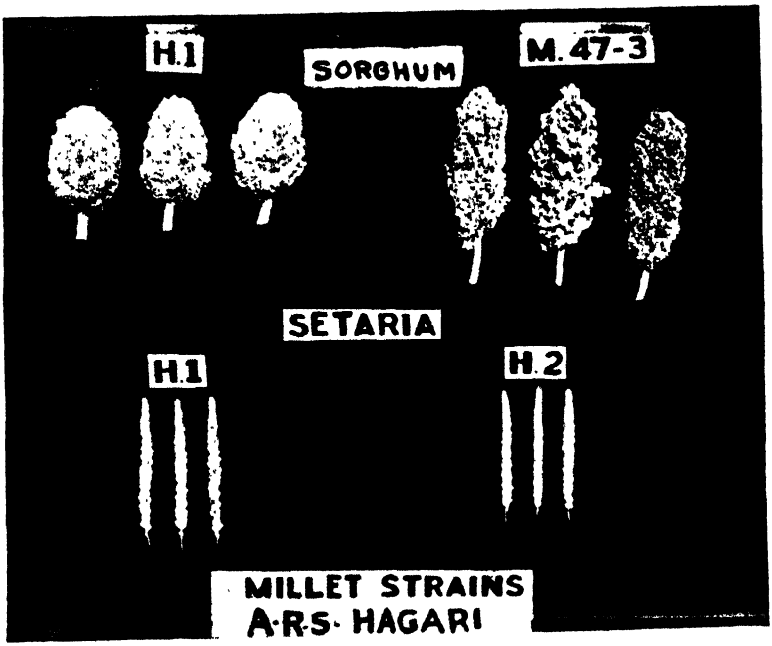


Plate 16 (*d*).—*Improved millets strains.*

Strain number.	*Sowing season.*	*Remarks.*
	Agricultural Research Station, Guntur.	
G. 1 ..	September-October to December-January.	Pyru Jonna selection.
G. 2 ..	Do.	Do.
G. 3 ..	June-July to October-November.	Punasa Jonna selection.
G. 4 ..	Do.	Do.
	Agricultural Research Station, Nandyal.	
N. 1 ..	June-October to October-February.	Popular in Kurnool.
N. 2 ..	Do.	Do.
N. 3 ..	Do.	Popular in Kurnool and Proddatur.
N. 4 ..	Do.	Do.
N. 5 ..	Do.	Popular in Cuddapah.
N. 6 to N. 9.	Do.	For the various sub-tracts in the main tract.
	Agricultural Research Station, Hagari.	
H. 1 ..	October to February ..	White grain. Compact ear-heads.
M. 47-3 ..	Do. ..	White grain. Loose ear-heads.
	Agricultural Research Station, Koilpatti.	
K. 1 ..	January to May (irrigated) and September-October to December-January. (Rainfed).	....
	Millets Breeding Station, Coimbatore.	
CO. 1 ..	July August to December-January.	Periamnjal Cholam, popular in Coimbatore and adjacent districts; also good for fodder.
CO. 2 ..	Do.	Talaivirichan cholam, popular in Coimbatore, Salem, Tiruchirappalli and Chittoor districts. (Rainfed).
CO. 3 ..	Do.	Talaivirichan cholam, popular in Coimbatore, Salem, Tiruchirappalli and Chittoor districts, Grains pearly. (Rainfed).
CO. 4 ..	February-March to May-June.	Sencholam, grown irrigated. Yields 2,000—2,500 lb. of grain per acre.
CO. 5 ..	March to June	Chinnamanjal cholam. Duration 100 days. Irrigated. Yields 2,200—2,750 lb. of grain per acre.
CO. 6 ..	Do.	Chitraivellai cholam. Duration 115 days. Popular in Coimbatore district.
CO. 7 ..	Do.	Vellai cholam. Irrigated. Duration 110 days. Yields 2,500—3,000 lb. of grain per acre. Popular in Coimbatore taluk.
CO. 8 ..	Do.	Ennai Vellai cholam. Irrigated. Duration 100 days. Yields 2,500—2,700 lb. Popular in Avanashi and Gopichettipalayam taluks of Coimbatore district.
CO. 9 ..	Do.	Vellai cholam (kesari). Irrigated. Duration 95 days. Yields 2,500—3,000 lb. Becoming popular in many districts especially Coimbatore, Tiruchirappalli, Tirunelveli and Ramanathapuram districts.

Strain number.	*Sowing season.*	*Remarks.*
	Millets Breeding Station, Coimbatore—cont.	
CO. 10	.. March-August (Irrigated). June-December (Rainfed).	A fodder variety. Yields 64,000 lb. of green fodder and 800—2,000 lb. of grain per acre under irrigation.
CO. 11	.. March-June (Irrigated). August-November (Rainfed).	Fodder cholam. Yields from 15,000 to 20,000 lb. of green fodder and 2,000 lb. of grain per acre under irrigation.
CO. 12	.. January-March or April-June.	From Uppam or Mottai vellai cholam of Coimbatore. Irrigated. Popular in Coimbatore, Tiruchirappalli and Chittoor districts. Duration 90 days.
CO. 13	.. January-February to March-April.	From Ennai vellai cholam of Coimbatore district. Irrigated. Duration 100 days.

Hybridisation.—Recourse was taken to hybridisation for widening the scope for selecting desirable types. From the progenies of crosses between *Periamanjal cholam* (*Sorghum durra*) and *S. caffrorum*, two selections with juicy stems have been taken for yield tests. From another cross between two high-yielding selections of *Periamanjal cholam* (CO. 1 and AS 3596) 114 selections were taken to choose the best of them as superior strains. Seven hundred and fourteen selections from crosses between *Talaivirichan cholam* (*Sorghum roxburghii*) and *S. conspicuum* types are also under tests to evolve a *Talaivirichan* strain with a bold-grain. Similarly, in order to improve the grain size in the *Chinnamanjal* strain CO. 5, it was crossed with a bold-grained African type named "*Sufra*" and the selections from these crosses are under study. Several crosses have been made in a similar manner to improve the grain size in *Irungu* types suited for the Tirunelveli tract. A juicy-stemmed *Talaivirichan cholam* (AS 5945) was crossed with AS 1093, for improving the quality of straw of the *Talaivirichan* strain and four selections from these are in the final stages of yield tests, along with another mutant, AS 7463, with juicy-stems. Similarly *kaki jonna*, a fodder variety with pithy stem was crossed with an American type "*Honey sorgo*" for improving the quality of fodder and promising selections from these await yield tests. A number of other crosses also have been made for improving the quality of fodder in irrigated sorghums and are under study at the Central Millet Station at Coimbatore.

Evolution of sorghum varieties resistant to Striga.—Rainfed sorghum crops in Madras are often subject to the attack of root parasites *Striga lutea* and *S. densiflora* which in some years assume a serious form. *Striga* occurs as a serious pest of sorghum in the *Periamanjal cholam* tract in the district of Coimbatore and in the *Patcha jonna* tract of the Kurnool district. The work was first taken up for the Coimbatore tract and the world collection of sorghum types available at the Millet Breeding Station was gone through to pick out resistant types. After extensive studies during years of heavy *Striga* infestation, two types, "*Bonganhilo*" from Africa (AS 4000) and "*Bilichigan*" of Bombay (AS 4693) were

chosen as resistant to the parasite and both were crossed with the *Periamanjal cholam* strain CO. 1 and the progenies were tested for Striga-resistance by growing them in a field heavily infested with Striga. Three promising selections are available at present for further tests and purification before release as Striga-resistant strains of *Periamanjal cholam*.

A scheme of Striga research has also been started in 1949 under the joint auspices of the Indian Council of Agricultural Research and the Madras Government. The work is programmed to be carried out at four centres, viz., at Coimbatore, Hagari, Nandyal and Guntur, with a variety of control measures like Agronomic operations, chemical sprays and the breeding of resistant types.

Agronomic experiments.—It has been found by tests carried out at the Millets Breeding Station, Coimbatore, that sorghum seed retains its viability longer in the earhead than when kept loose in a bottle. The maximum ' period ' for which the germination capacity is retained at high levels is 24 months.

With increasing depths of sowing, a progressive decrease in germination and in the number of secondary roots has been noted in sorghum. An experiment was conducted in 1948 with seed rates varying from six to 21 lb. per acre and it was found that for *Periamanjal cholam*, a seed rate of 9 lb per acre gave the maximum yields of grain. For fodder, the optimum seed rate was found in the Central Farm to be 80 lb. per acre. Higher seed rates improve the quality of fodder as the stalks get thin and fine but the outturn is less. At Koilpatti, experiments carried out during 1935 to 1941 with " *Irungu cholam* " have shown that a seed rate above 60 lb. per acre did not materially improve the yield or quality of fodder. The local ryots' practice of using 120 to 150 lb. of seed per acre is thus very high and wasteful of seed. At Guntur, experiments conducted during 1937 to 1939 showed that 40 lb. for a fodder crop and 18 lb. for a grain crop were the optimum seed rates.

Spacing.—For rainfed *Periamanjal cholam*, two links between rows was found to be the optimum spacing at Coimbatore, while at Hagari (Bellary district) the optimum spacing for *jonna* was 18 inches between drill rows. At Koilpatti in 1927–28 sowing in rows with the help of drills was compared with broadcasting. There was no difference in yield between the two treatments but drill sowing is desirable as it facilitates subsequent operations like weeding and hoeing by cattle power and harvesting can be done more easily and expeditiously.

Planting.—In parts of Visakhapatnam, Chittoor, North Arcot, Salem and Madurai districts, irrigated sorghum is transplanted with seedlings raised in a nursery. To compare the economics of this practice with direct sowing, experiments were conducted for three consecutive seasons at the Millets Breeding Station and it was found that direct sowing was the better practice.

Cultural operations.—Experiments conducted at Koilpatti have shown that ploughing was not an indispensable operation for securing normal yields in "*Irungu cholam.*" Keeping the land free from weeds appears to be quite as good as ploughing with a mouldboard plough in this tract at any rate. At Hagari too it was found that deep ploughing was not essential in black soils and was apparently useful only as a means of eradicating stubborn weeds like "Cynodon dactylon." Ploughing experiments at Nandyal, with different types of ploughs, and varying number of ploughings and comparing their effects with the use of *gorru* (drills) and *guntaka* (blade harrows) over a number of years, failed to show any significant differences. At Guntur, the effect of ploughing with different types of ploughs like the Victory, Sabul, Monsoon and country ploughs was studied from 1928 to 1931, but no real difference could be seen between any of these, but experiments on preparatory cultivation, given by country plough, *guntaka* and *gorru* from 1941 to 1943, indicated that the best yields were secured when maximum cultivation and ploughings were given.

At Hagari, two intercultures were found to be the optimum for *jonna* (Sorghum).

Bunding.—Experiments at Hagari by putting up small 6-inch bunds and dividing the fields into small plots of five to ten cents showed that in years of deficient rainfall, the increase of sorghum yield as a result of bunding was more marked than in years of sufficient or heavy rainfall. At Koilpatti and Guntur also bunding was tried as a means of conserving moisture and preventing erosion, but no significant difference was noticeable in the yields from bunded and non-bunded fields. This is probably because the rainfall is higher in these two stations than at Hagari where the average is only 18 inches per annum.

Manuring.—Application of farmyard manure to '*Irungu*' sorghum at Koilpatti did not improve the yield to any significant degree. At Nandyal, the experiments indicated that it was more economical to apply farmyard manure to the sorghum crop than to the succeeding crop of cotton, as the cereal responded well to manuring and a sufficient residual effect persisted in the second year for the cotton crop. At Hagari, on the other hand, no residual effects were apparent on sorghum with any of the different doses of farmyard manure that were tried.

An experiment to compare the relative merits of compost and cattle manure was conducted for three years (1939-1942) at the Central Farm, Coimbatore. The results showed that both these manures were helpful in increasing yields to more or less the same degree. Higher doses of either manure gave significantly higher yields. At Nandyal in a similar experiment from 1939 to 1942, both compost and cattle manure gave higher yields than no manure, only in the case of straw yield, but not in grain. In the case of sorghum for fodder, compost was more beneficial than all other

treatments. At Hagari, 'Indore' compost and farmyard manure were compared and their residual effects also studied. Both were better than no manure and between the two, farmyard manure was better than compost.

Green manure.—Incorporation of green manure in dry lands for a sorghum crop gave improved yields at Guntur in 1936-1938 but a similar trial at Nandyal did not show any significant difference in grain yields, either with or without the addition of superphosphate to the green manure.

At Guntur, sorghum yield was improved by an application of 500 lb. of groundnut cake and 1,000 lb. of farmyard manure per acre as against no manure. The possibility of using molasses as a manure for irrigated sorghum was tested at Hagari in 1940–41. Molasses when applied at eight tons per acre gave higher yields in both grain and straw, but the increase was not statistically significant. Another experiment at Hagari, showed that application of fertilizers like ammonium sulphate and superphosphate did not increase the yields in sorghum, but at Guntur in 1934, direct application of ammonium sulphate and superphosphate over a basal dressing of farmyard manure for *Pyru jonna* (sown in October) gave up to 67 per cent increase of yield over the control.

Pests and diseases.—A more detailed account of the various insect pests and diseases that attack sorghum will be found in Chapters 22 and 23, and hence only a list of these is given below, in the descending order of importance :—

Insect pests of sorghum—

(1) The earhead bug. (*Calocoris angustatus L.*)
(2) The moth-borer. (*Chilozonellus S.*)
(3) The red hairy caterpillar. (*Amsacta albistriga M.*)
(4) The deccan grass hopper. (*Colemania sphenaroides, B.*)
(5) The fly maggot-borer. (*Antherigona indica M.*)
(6) The shoot caterpillar. (*Cirphis unipunctata H.*)
(7) The shoot bug. (*Perigrinus maidis D.*)
(8) Plant lice. (*Aphis maidis F.*)
(9) Stored product pest. (*Calandra oryzae L.*)
(10) Stored product pest. (*Rhizopertha dominica F.*)

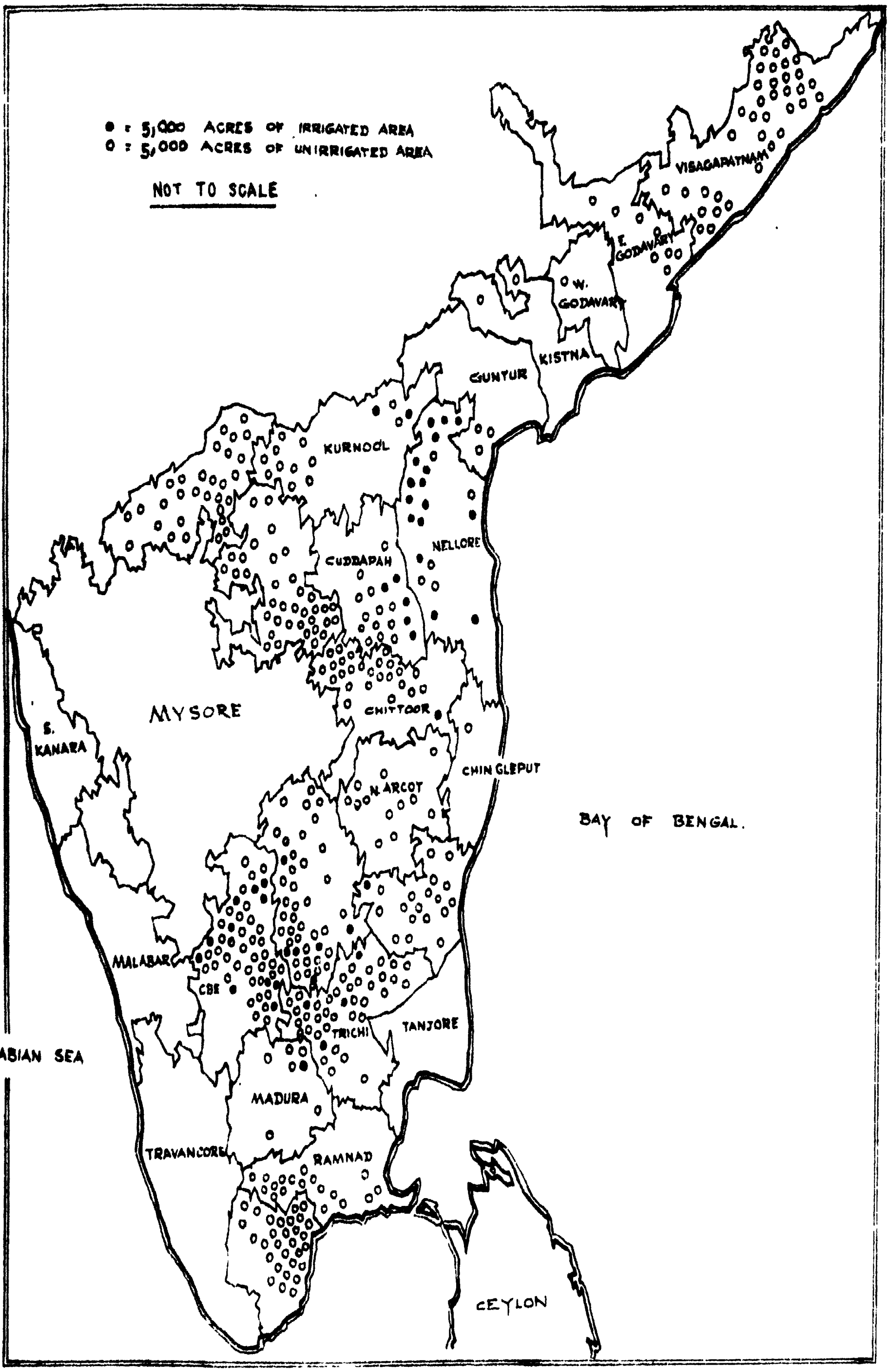
Diseases of sorghum—

(1) Long smut. (*Tolyposporium ehrenbergi.*)
(2) Whole earhead smut. (*Sphacelotheca reiliana.*)
(3) Rust. (*Puccinia purpurea.*)
(4) Leaf shredding disease. (*Sclerospora sorghii.*)
(5) Striga. (*Striga lutea* and *Striga densiflora*—Root parasites.)

Harvesting and yields.—Sorghum plants when ripe are harvested by means of a sickle, cutting them at four to six inches above ground level. In the Ceded districts, where the crop is allowed to get dead ripe before harvesting, the plants are usually pulled out. The yields vary very widely according to soils, seasons, the nature

DISTRIBUTION OF BAJRA CROP IN MADRAS STATE

(1948-49)



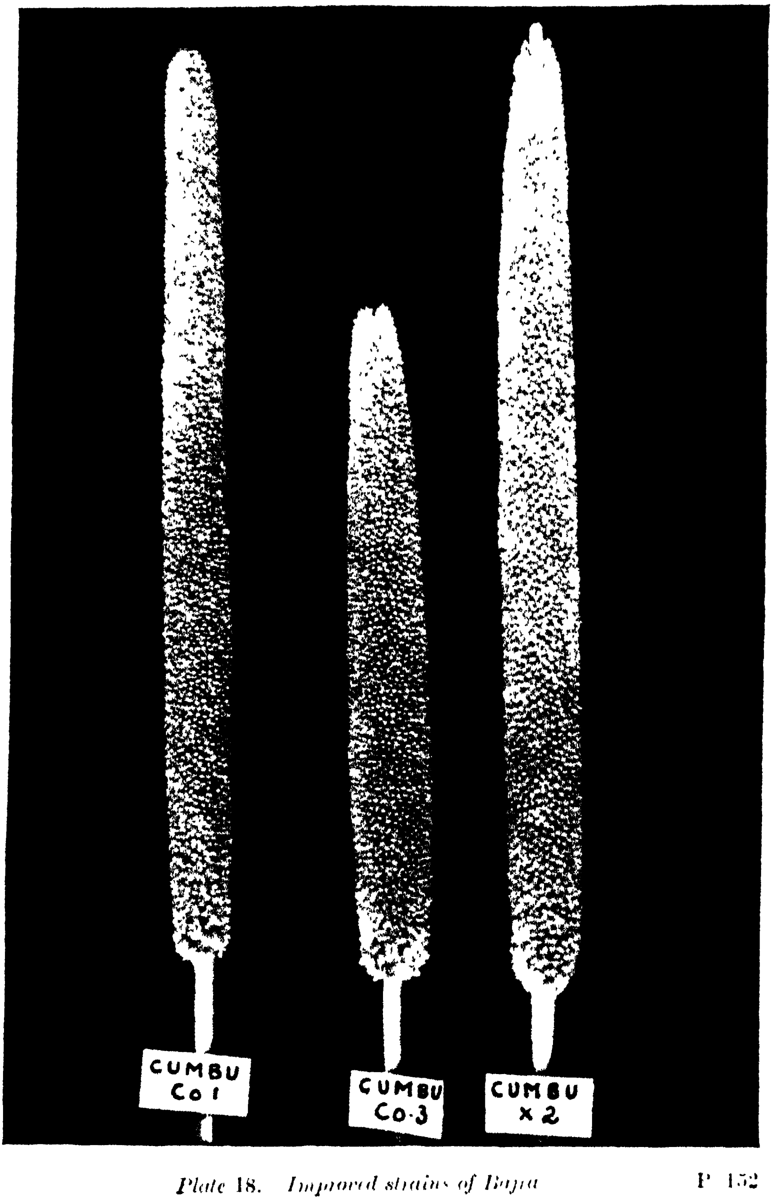


Plate 18. Improved strains of Bajra

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Districts.	Total area.	Irrigated.	Unirrigated.
	ACS.	ACS.	ACS.
1 Coimbatore	297,400	61,400	236,000
2 Salem	295,000	36,000	259,000
3 Tiruchirappalli	239,300	37,300	202,000
4 Tirunelveli	192,540	3,540	189,000
5 Guntur	190,450	2,050	188,400
6 Visakhapatnam	179,720	720	179,000
7 Anantapur	170,120	120	170,000
8 Chittoor	143,200	18,200	125,000
9 Ramanathapuram ..	140,320	6,320	134,000
10 Bellary	137,110	110	137,000
11 Nellore	113,200	80,000	33,200
12 Cuddapah	109,800	28,300	81,500
13 South Arcot	91,450	8,550	82,900
14 North Arcot	73,400	13,400	60,000
15 Kurnool	66,600	12,000	54,600
16 East Godavari	61,300	..	61,300
17 Madurai	42,500	11,300	31,200
18 Krishna	20,400	..	20,400
19 Chingleput	14,370	3,070	11,300
20 West Godavari	12,900	..	12,900
21 Tanjore	5,900	1,190	4,710
22 Malabar	10	..	10
23 The Nilgiris	10	..	10
Total ..	2,596,600	323,570	2,273,030

The average annual production of bajra grain in this State is estimated at six lakhs of tons.

Climate and soils.—Bajra can be grown in regions of low rainfall with 17 to 30 inches per annum, in places where even sorghum fails to come up well. It is shorter in duration than sorghum and is grown both as a pure crop and also mixed with a variety of other crops like redgram, horsegram or lablab, and sometimes mixed with blackgram, *gogu* or gingelly in black cotton soils. The crop is cultivated on a wide variety of soils; from black soils to various grades of red, gray and even sandy soils, mostly as a rainfed crop and to a small extent under irrigation as a hot weather crop.

Varietal introductions and trials.—In the same way as in sorghum, a wide collection of samples from different parts of India and other countries was gathered and studied in the Central Millets Station at Coimbatore. Subsequently the work was extended to other stations of the State such as Anakapalle and Koilpatti. Following the same methods of selection as adopted for sorghum, a number of improved strains were evolved and these are listed below. (Plate 18.)

By selection.—The following improved strains have been released :—

Strain number.	Sowing season.	Remarks.
	Agricultural Research Station, Anakapalle.	
AKP. 1 ..	May-June to August-September.	From local *ganti.*
AKP. 2 ..	Do.	Do.
	Agricultural Research Station, Koilpatti.	
K. 1	February-May irrigated and October-January rainfed.	Popular in Tirunelveli and Ramanathapuram.
K. 2	Do.	Popular in Ramanathapuram.
	Millets Breeding Station, Coimbatore.	
CO. 1	March-April to June-July irrigated and September-December rainfed.	A selection from African type; duration 85 days. Suitable for Guntur, Chittoor, North Arcot, Salem, Coimbatore and other districts. Contains 15·5 per cent protein. Yields 1,500 to 2,000 lb. of grain under irrigation and 900 lb. under rainfed conditions.
CO. 2	July-Septemper to October-December.	A selection from a Bombay variety, suitable to Coimbatore and Chittoor districts. Duration 90 days. Yields 600 to 900 lb. per acre.
CO. 3	March-April to June-July ..	From Kottapuli cumbu ; duration 80 days ; irrigated variety ; yields 1,200 to 2,000 lb. of grain per acre.
Crosses I and II (Hybrids).	Do. ..	From X-rayed material ; yields from 1,500 to 2,000 lb. under irrigation ; suitable for southern districts.

Fundamental studies—Germination tests.—Germination tests made on seeds gathered from various sizes of seeds do not show and difference in their sprouting capacity. The size of the seed showed a progressive decline with the lateness of the earhead.

Anthesis and pollination.—The inflorescence of the pearl millet is a spike, being composed of a central rachis and a number of seriately disposed, closely packed fasicles. Each fasicle includes one or more spikelets and a whorl of free bristles. But these bristles are not common in the cultivated varieties. The most noticeable feature of the ear-head on emergence is its protogynous condition with its mass of protruding, glistening stigmas which remain fresh for 12 to 24 hours, according to weather conditions. Lodicules are absent in the spikelets of this millet. The emergence of anthers from the flowers was observed. Anthesis goes on throughout the day and night, the maximum flowering being between 10 p.m. and 12 midnight. During the day, there is a slight rise prior to 10 a.m. The weakest flowering is at 4 p.m., periods of high humidity and a fall in temperature are marked by increased anthesis. (Plate 19.)

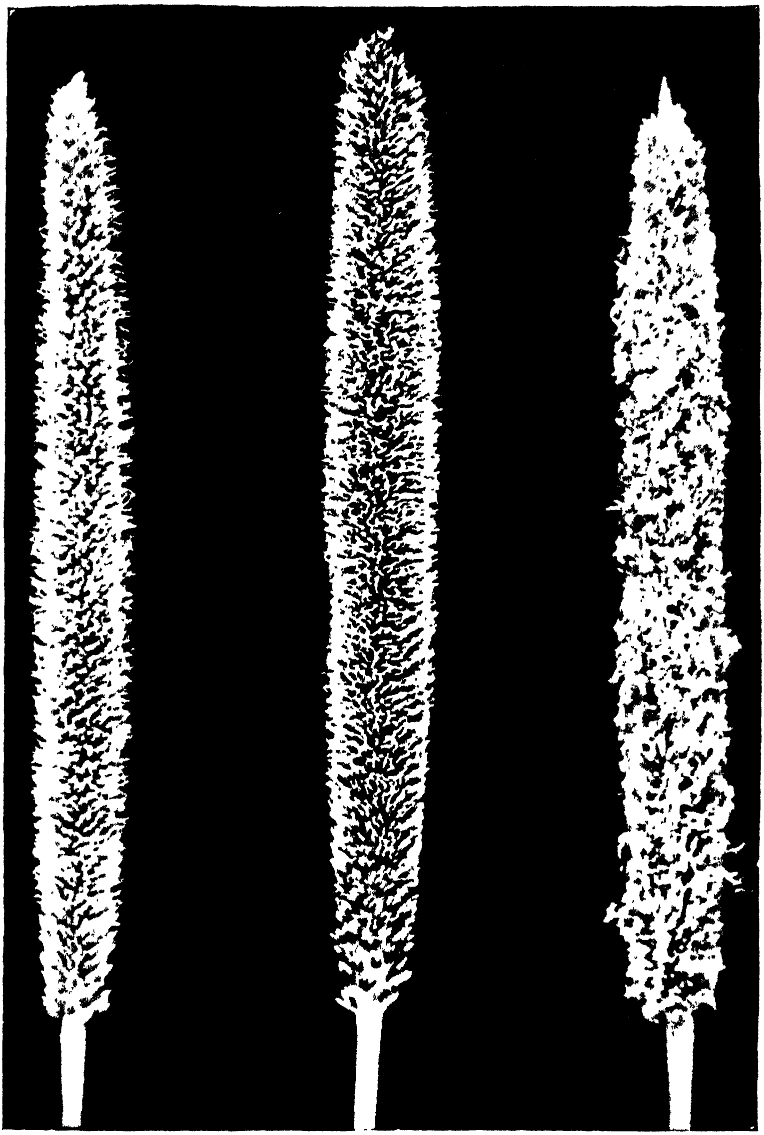


Plate 19.—*Anthesis in Bajra heads* P. 155

Basal branching.—An odd seed of pearl millet taken from some sorghum seed imported from Nigeria, gave an earhead with unusual length. The basal portion of this ear was normal and unbranched. When seeds from this plant were sown, segregations were noticed for normal heads with unbranched bases and those with branched bases. This branched 'atavistic' condition is recessive to the normal unbranched form.

Bristles.—The fascicles which compose the ear are surrounded by 30 to 70 bristles. Bristled spikelets have been met with in certain types. These bristles were found to be a prolongation of the fascicle axis at the end of which the spikelet is borne as a lateral appendage. *Pennisetum echinurus*, an African species, is full of long bristles. Unlike the normal types, bristled bajra has a reputation for keeping off birds from pecking the grains. But in the varieties studied, the longer the bristles, the greater the shedding of the fascicle and lesser the density of packing of the grain. The condition in which the bristles are suppressed in expression and remain below the grain surface is recessive.

Interspecific crosses—*Pennisetum leonis*, a new form from Africa, was crossed with Coimbatore variety. The *Pennisetum leonis* characters were found to be dominant.

An autotriploid was observed in the progeny of a sterile bajra plant. The vegetative characters of this did not differ in any way from those of the diploid. The number of chromosomes of this plant was 21 (2n), while the normal diploid showed only 14. The meiosis showed a high frequency of trivalent formation. The most common configurations were chains of three frying pans and Y-types. Rings of three chromosomes were noted and in a few cases higher associations than three were met with. These are considered to be due to segmental interchange. Fragmentation and bridge formation were frequent at the first and second anaphases. In the trivalent, inversion has taken place in one of the homologues, and this plant therefore belongs to the class of structural hybrids. Tetrads were normally formed and some free pollen was obtained but the plant was highly sterile and all attempts to get seed out of it were unsuccessful.

Studies in hybrid vigour.—Bajra being a normally cross-pollinated plant, crop improvement in this was sought to be accomplished by utilizing hybrid vigour as was done in maize in the United States of America. The extent of natural crossing in this crop was first determined in 1948 in different parent lines laid out in different systems of sowing. The percentage of natural crossing was found to vary from 27 to 80 according to the treatments, the higher percentages being obtained by sowing the parents in adjacent rows two links apart on the same day (77·8 per cent.) and also by mixing the seeds of the two parents in the same row, in the proportion of one female to three male parents (75·7 per cent). Since bajra is hermaphrodite whereas maize is monoecious, the actual technique of producing hybrid seed in bajra had to be different

from the one adopted for maize. The only helpful feature in this crop is the protogynous nature of the spikelets.

By 1949, two hybrids X-1 and X-2 were evolved and tested for yield in ryots' fields in different bajra-growing districts. They were found to give an average increased yield of 40 per cent over local varieties in the southern districts. Evolution of other hybrids suited for the northern districts is in progress along with the inbreeding of a number of parent lines of good combining ability as judged by their hybrids, in order to stabilize them for use as parent stock for further crosses.

Cytological studies.—The chromosome number of bajra is 2n = 14 in the cultivated varieties and 2n = 21 in the autotriploid that was referred to earlier. A cross was made between a cultivated diploid bajra and the wild tetraploid species, *Pennisetum purpureum* with 2n = 28. The hybrid was an allotriploid with 2n = 21. As this primary hybrid was found to be a good fodder grass, a fertile amphidiploid of this hybrid was produced, with 2n = 42. The progenies of this fertile plant are under test for their suitability as fodder crops. In the sterile primary hybrid itself, a very small percentage of seed setting was observed, giving rise to heteroploid plants with chromosome numbers of 2n = 42, 22, 21. The hybrid and progeny were in addition found to be rust-resistant as well and this valuable feature is now being transferred to the cultivated species by means of suitable crosses.

Various types of sterility have been observed in bajra. One type behaves as a simple Mendelian character in inheritance while other types of sterility are apparently chromosomal in origin, being caused by failure of synapsis, segmental interchange, fragmentation of chromosomes and agglutination of chromatin resulting in abnormal meiosis.

Agronomic Experiments—Sowing.—A trial was made in 1915–17 to see if bajra could be sown dry in the field before rains are received, but the results proved that dry sowing was not so good as after rains. Drilling versus broadcasting was tested as Koilpatti in bajra in 1907 and again in 1931–32 and it was found that both gave similar results. There was also no difference in yields between bajra drilled in rows one foot or one and a half feet apart, but from the point of economy and convenience of intercultivation, drilling in rows 18 inches apart was decided as the most suitable.

To compare the relative merits of direct sowing and transplanting bajra, experiments were carried out at Coimbatore in the Millets Station and it was noted that both the transplanted and the earliest sown plots gave more yields than the control. The extra cost in raising a nursery and transplanting was covered by the increased yield from the planted crop.

Cultural operations.—An experiment was conducted at Koilpatti between 1935–47 with three treatments, (1) working with Monsoon plough for the preparatory cultivation for bajra (2) working with

guntaka, and (3) no ploughing. No distinct difference could be seen between these treatments in point of bajra yields, showing that this crop does not require a deep preparatory cultivation. At the same station, experiments on bunding the fields to prevent run off of rain water were conducted between 1933 to 1945, but no effect was seen with bunding, owing probably to the fact that sufficient water for bajra growth soaks in even without bunding.

Manuring--Koilpatti.—Farmyard manure stored in three different methods, viz., loose box, byre and heap were applied to bajra, but though all three were better than no manure, no difference could be seen in the yields from different systems of storing the farmyard manure. It was also noted from other trials that broadcasting the manure in the field was quite as useful as drilling it along with bajra seed in the rows at sowing time.

Compost v. *Farmyard manure* (*Agricultural Research Station, Palur*).—Bangalore compost, modified Indore compost and farmyard manure were tried on bajra at five and ten tons per acre against no manure as control. The best yields were obtained in plots manured with Indore compost at 10 tons followed by the 5 tons per acre dose. The residual effect of these manures on bajra, following ragi was not very appreciable.

The effect of supplying nitrogen in various doses to bajra in the form of ammonium sulphate and groundnut cake with and without superphosphate was tested at Koilpatti. These manures were applied both directly to bajra and indirectly to the crop preceding bajra and their residual effects studied. The direct application of ammonium sulphate at 2 cwt. per acre or groundnut cake at 500 lb. per acre along with 1 cwt. of superphosphate to bajra, increased the yield by more than 100 per cent. If these manures were applied first to cotton, their residual effect on the bajra crop that followed was as high as 40 per cent over no manure. Taking into account the cost of manures and the cost of applying them, direct application to cotton was more profitable than applying them to bajra. Nitrogen supplied in the form of groundnut cake was more useful than in the form of ammonium sulphate.

At the same station, trials were carried out from 1923–26 to see if superphosphate and calcium cyanamide alone or in combination would improve bajra yields. The results showed that cyanamide by itself or with superphosphate increased bajra yields, but that super by itself had little effect.

Pretreatment—(*Millet Breeding Station, Coimbatore*).—To assess the utility of cow's urine as a manure, seeds of bajra were soaked in 100 per cent, 10 per cent and 1 per cent cow's urine and compared with the yield obtained from control seeds soaked in distilled water alone for four hours. The 100 per cent cow's urine treatment gave significantly higher yields than the other treatments which were all more or less equal to one another.

Pests and diseases.—Bajra is subject to more or less the same pests as sorghum and the same diseases. The major pests are the red hairy caterpillar (*Amsacta albistriga* M) and the Deccan grasshopper (*Colemania sphenaroides* B) and in addition to these a few minor pests like the black headed hairy caterpillar, the plant bug *Nezaria viridula* and blister beetles are also found sometimes.

The chief diseases are: Smut (*Tolyposporium filiferum*) and the green ear disease Sclerospora graminicola (*Sclerospora graminicola*). The appropriate remedial measures will be found along with the description of these pests and diseases in Chapters 22 and 23.

Harvesting and yields.—The crop matures in four or five months and is harvested by cutting off the earheads with sickles. When the tillering is profuse as in the case of irrigated crops, the harvest has to be done twice, as all the earheads do not ripen at the same time. The cut heads are removed to the threshing floor and threshed out either by beating with sticks or treading them under the feet of cattle or by using a stone roller as in Mysore. Storing and milling are similar to sorghum. The yields are very widely variable ranging from 600 to 900 lb. for the pure crop under favourable rainfed conditions and from 1,000 to 2,000 lb. of grain from an irrigated crop.

Food value of bajra.—The grain is consumed either as " *San-* fodder.

Food value of bajra.—The grain is consumed either as " *Sangati* " or as cakes. ' *Sangati* ' is made by converting the grain into flour and cooking it in water till it becomes a paste of suitable consistency. Cakes are made from bajra flour just as with any other flour. The average chemical composition of the grain is as below. (Akroyd.)

	PER CENT.
Water	12·4
Albuminoids	11·6
Carbohydrates	67·1
Fat	5·0
Crude Fibre	1·2
Ash	2·7

RAGI—(*Eleusine coracana, Gaertn*).

The Finger Millet: (Telugu: *Ragi; Chollu;* Thaidalu; Tamil: *Ragi*, Keshvaragu; Kannada: *Ragi*; Malayalam: *Muthari*; Hindustani: *Mandwa, ragi.*)

Production and importance.—Ragi is a widely cultivated crop of the tropical and sub-tropical regions of the world, being grown in Africa, Madagascar, India, Ceylon, Malaya, China and Japan. In India this cereal occupies about 5·5 million acres, of which Madras and Mysore account for nearly four million acres. Madras has an area of 1·75 million acres under ragi, which represents about 6 per cent of the total area under cultivation. The normal ragi area in the different districts of the State is given below in descending order of acreage. Out of the total area of 1·75 million acres, 52 per cent is raised under irrigation and the remainder as a rainfed

DISTRIBUTION OF RAGI CROP IN MADRAS STATE

(1948-49)

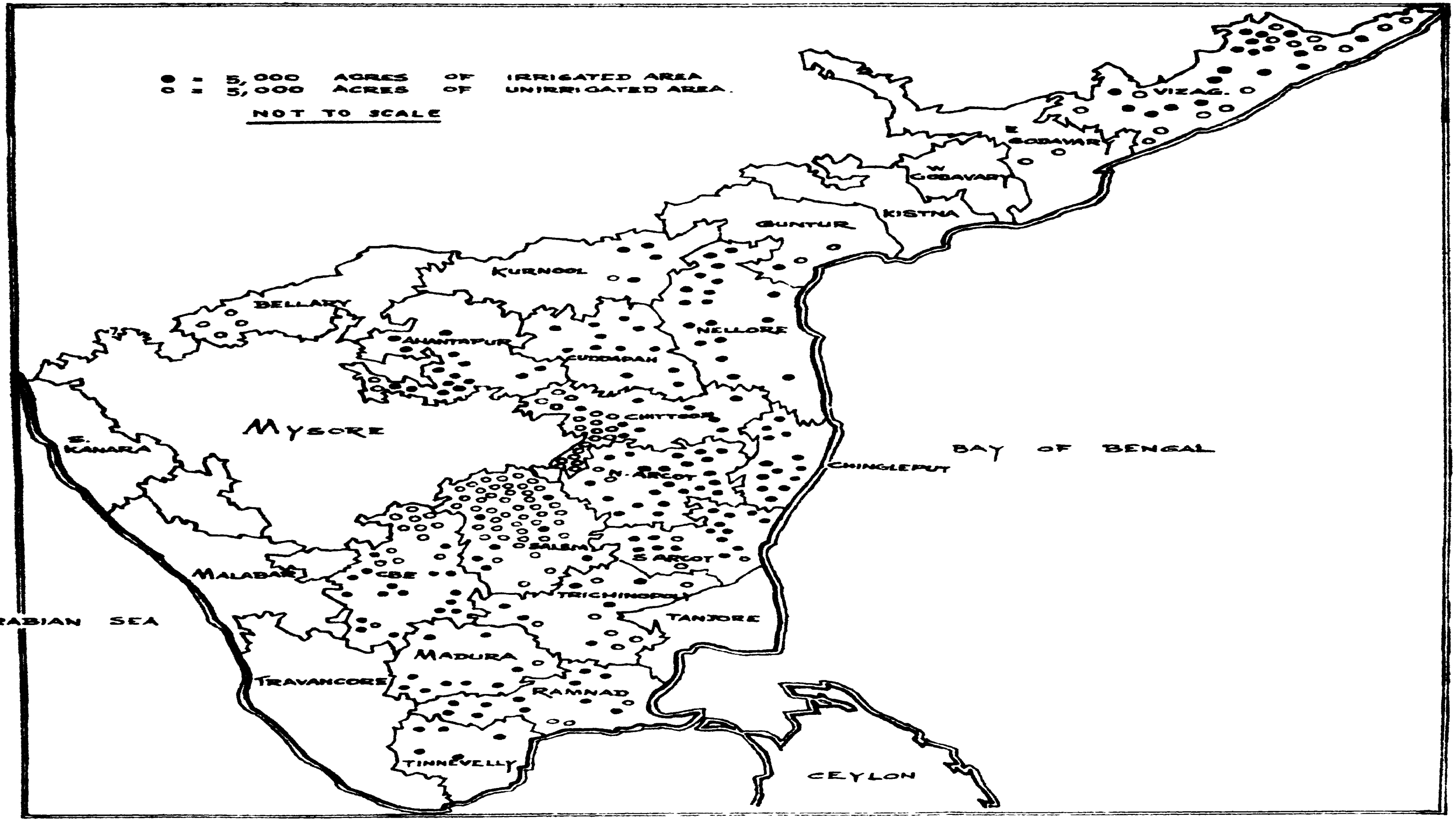


Plate 21.—*The Ragi plant* (*finger millet*). P. 162

crop. The average annual production of grain is estimated at 760,550 tons per year in Madras State.

District.	Total area.	Irrigated.	Unirrigated.
	ACS.	ACS.	ACS.
1 Salem	280,900	33,900	247,000
2 Visakhapatnam ..	249,000	122,000	127,000
3 Coimbatore	174,600	100,000	74,600
4 Chittoor	147,100	55,700	91,400
5 Anantapur	98,900	80,700	18,200
6 North Arcot	97,000	75,500	21,500
7 Ramanathapuram ..	91,700	48,000	43,700
8 Chingleput	88,000	65,300	22,700
9 Nellore	83,200	77,700	5,500
10 South Arcot	76,200	60,400	15,800
11 Cuddapah	62,290	56,300	5,990
12 Madurai	60,200	40,300	19,900
13 Tiruchirappalli ..	56,700	31,300	25,400
14 Tirunelveli	33,060	31,200	1,860
15 Bellary	28,090	6,690	21,400
16 East Godavari ..	26,380	280	26,100
17 Kurnool	21,520	17,400	4,120
18 Guntur	17,680	7,280	10,400
19 Tanjore	15,720	10,700	5,200
20 Malabar	11,100	..	11,100
21 West Godavari ..	9,440	740	8,700
22 Krishna	8,500	700	7,800
23 South Kanara	6,410	..	6,410
24 The Nilgiris	4,420	..	4,420
Total ..	1,748,110	922,090	826,020

Climate, soils, etc.—Unlike rice, ragi can be grown in practically all the twelve months of the year though in actual practice there are two well-marked seasons in Madras. The most important is the main season where the sowing is done in May to June. The other season is from November to the middle of January. This is known in the northern districts as the "*pyru*" (*cold weather*) season. Sometimes in wet lands, ragi is also grown in December–January after the harvest of a rice crop. In dry lands, the sowing is generally done with the commencement of the South-West Monsoon in June–July.

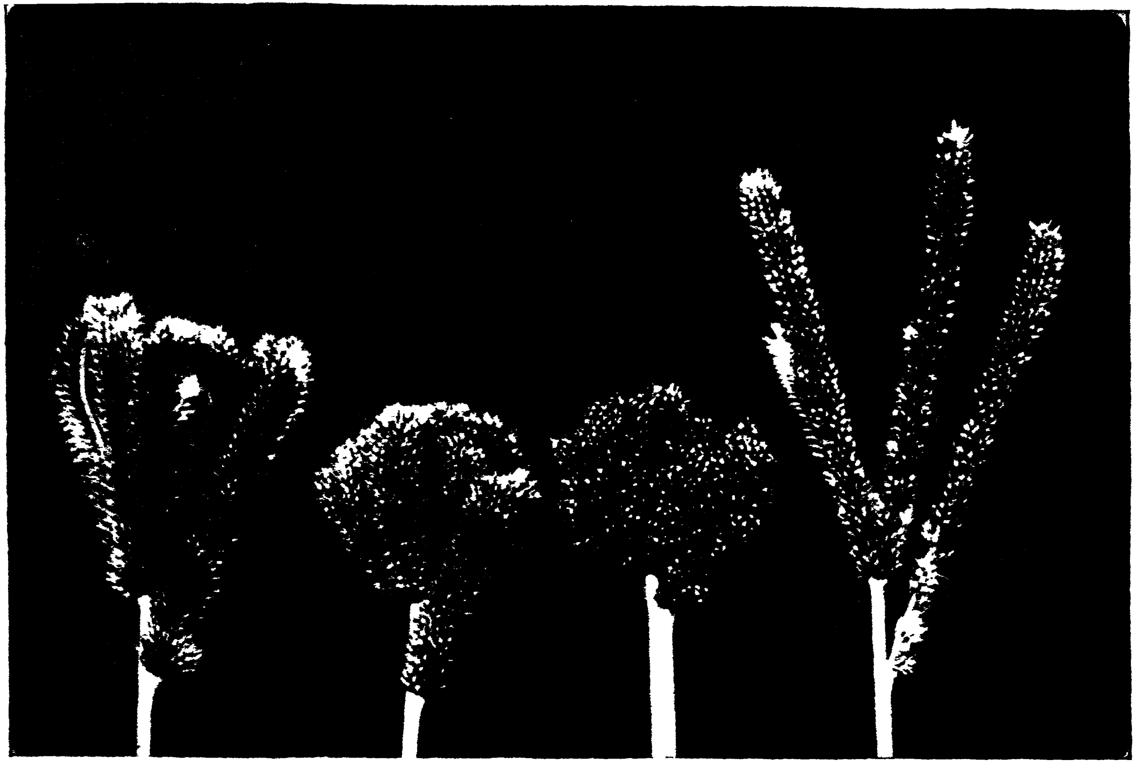
Ragi can be grown on a wide variety of soils, from the very poor to the very fertile, and can even tolerate a certain degree of alkalinity in soils, but thrives best on good arable land where the soil is a well-drained loam or clay loam. (Plate 21.)

Sowing.—The land is prepared after the harvest of the previous crop by giving two or three ploughings, applying manure and ploughing it in. After bringing the soil to the proper tilth, the bunds and channels are formed, and the field thrown into beds 10 to 12 feet square and levelled. Seedlings are raised in carefully prepared nurseries which receive heavy dressings of cattle manure and wood ashes. The seed-beds are two yards square and slightly raised to facilitate good drainage. The ragi seeds are sown thinly and lightly stirred in and water is let in carefully to prevent the seeds getting washed off. The usual seed rate is from five to six pounds per acre of planting area.

In dry lands, the crop is generally sown broadcast after receipt of sowing rains. The seed is broadcast evenly and covered by a light ploughing. A brush harrow or log of wood is also dragged along the surface with the object of levelling it and packing the surface soil to a certain degree. In Mysore it is common to use a special type of drill for sowing ragi with twelve tynes three inches apart. In Visakhapatnam there is a method of transplanting ragi seedlings on dry lands by raising a seed-bed about a month before the advent of sowing rains. With the receipt of rains, the seedlings are pulled out and planted in small clumps of twos and threes at regular intervals of four to six inches in plough furrows. Then seedlings get covered at the bases by the next furrow of the plough.

Varietal introduction and trials.—Adopting the same method as described in other crops like rice, sorghum and bajra, several improved strains of ragi have been evolved at the Millet Breeding Station, Coimbatore and other regional research stations like Hagari, Anakapalle and Koilpatti. These strains are given below :—

Strain number.	Sowing season.	Remarks.
	Agricultural Research Station, Anakapalle.	
AKP 1	May to August	*Punasa* ragi strain.
AKP 2	Do.	Do.
AKP 3	December-April	*Pyru* ragi strain.
AKP 4	Do.	Do.
AKP 5	Do.	Do.
AKP 6	August-December	Pedda panta strain.
AKP 7	Do.	Do.
	Agricultural Research Station, Hagari.	
H 1	(1) January to May (2) June to October	Grown in Bellary, Anantapur, Kurnool, Cuddapah, Nellore and Guntur districts.
	Millets Breeding Station, Coimbatore.	
CO 1	May-June to September-October.	Selection from *Gidda Aryam* of Salem; Irrigated crop, but can also be grown as a rainfed crop. Duration 120 days. Yields 2,000 to 2,500 lb. of grain per acre.
CO 2	Do.	From *Mutti ragi* of Coimbatore district; Irrigated. Duration 110 days. Yields 2,000 to 2,200 lb. grain per acre.
CO 3	(1) May to September (2) December to March	Mutant from Co. 1. duration 110 days. Popular in Coimbatore, Chingleput and North Arcot districts.
CO 4	May-June to September-October.	Selection from Palladam local type. Suitable for Ramanathapuram and Tirunelveli districts. Duration 130 to 140 days. Yield 2,000 to 2,250 lb. per acre.



Topcurved. *Incurved.* *Fistlike.* *Open*

Plate 22.—Earhead shapes in Ragi.

Fundamental studies (Millets Breeding Station, Coimbatore) Plant pigmentation.—Just as in rice and sorghum, in ragi too purple pigmented plants are dominant to green ones in inheritance. Five distinct types of pigmentations are met with, each showing a single factor difference over the next lower group, viz., violet purple, medium purple, dilute purple, localized purple and green throughout.

Earhead shapes.—Two factors are involved in the genetic manifestation of earhead variations. Either of these gives a short earhead and both together give a long ear. When neither of the two factors is present a very short earhead is produced. Another factor determines the density of disposition of the spikelets per unit length on the rachis. Various combinations of these genetic factors give rise to the characteristic earhead shapes in ragi, such as top-curved, in-curved, and fist-like. In addition to these, three factors are involved in determining the length of glumes in ragi spikelets, the short glume in normal cultivated types being conditioned by the presence of these three dominant factors functioning as inhibitors of glume length. (Plate 22.)

Grain colour.—The normal colour of ragi grain is brown and this colour behaves as a double dominant to the light brown. In ragi, the pericarp is not fused with the seed coat but peels off as a thin membrane. The brown colouration is found to be due to a tannic material deposited in the cells of the inner integument. The grain colour factors are also genetically related to plant pigmentation.

Albinism or the absence of chlorophyll pigmentation in the young seedlings was met with in ragi and studied in respect of its genetic behaviour. Albinism was found to be determined by two duplicate factors.

Cytological studies.—A cytological study of ragi showed that the 18 pairs of somatic chromosomes in *E. coracana* are all more or less uniform in size and shape. The organogeny of the spikelet has been described. The microsporogenesis is typical. Occasionally one or two univalents occur in the first division. They usually get included in the second division. Secondary pairing is evident. Megasporogenesis is also typical, the innermost of the linear tetrad functions. Polar nuclei remain separate till first division. The primary endosperm divides at the neighbourhood of the egg. Embryogeny is typical. Antipodals are three and very large. They are of the passive types. Grain is a free one. Hence the pericarp is ephemeral, only the inner seed coat persists.

The embryology of ragi was worked out. The chromosome numbers of some of the wild *Eleusine* species were worked out and reported for the first time. (*E. lagopoides* 2n = 36; *E. compressa* 2n = 45 *E. verticellata* 2n = 36.) A comparison of the meiosis of the *E. indica* (diploid with 2n = 18 and nearest

ally) with *E. coracana* (Ragi tetraploid with 2n = 36) was done. The cultivated species both by genetical and cytological evidence appear to be allotetraploid. *Dactyloctenium*, a genus closely resembling ragi was also investigated. The basic number and karyotype are different (*D. aegypticum* 2n = 48 *D. Scindicum* 2n = 48).

Some types of sterility were also worked out. One type was due to segmental interchange between two pairs of chromosomes. One type was simple mendelian resulting in non-dehiscence of anthers. Another type affecting the spikelets as a whole was termed " gappiness ". This was found to be due to suppression of the spikelet primordia on the rachis. Cytologically no disturbances were found. The inheritance of this type of sterility appears to be due to multiple factors.

Agronomic experiments—Seasons and varietal trial.—The ryots of Visakhapatnam district differentiate varieties grown in different seasons and grow a particular variety earmarked for a season in that season alone. To find if the varieties were season-bound or whether they could be grown with season inter-changed and to study their behaviour in different seasons, a trial was started in 1943–44. AKP 1 and AKP 2 of *punasa*, AKP 3, AKP 4, AKP 5, of *pyru* and AKP 6 and AKP 7 of rainfed ragi, all the seven strains were tried in three different seasons ' *Punasa* ' ' *Pedda panta* ' and ' *pyru* '. The results so far indicated that (1) short duration types alone are suitable for ' *punasa* ' while long duration types yield low and are subject to *Piricularia*, (2) short duration types of ' *Punasa* ' are not physiologically different from those of ' Pyru ' and can be interchanged and so there is the possibility of keeping one strain for both the seasons, (3) the long duration types of rainfed ragi gave good yields in ' *pyru* ' under irrigated conditions and hence the possibility of interchanging these different season strains and having a single strain for these two different seasons appear to exist. Thus the problem solves itself in finding out a high yielding strain in each of the short duration and long duration types. Strains AKP 1 and 2 are recommended for Punasa, AKP 6 for pyru and AKP 7 for rainfed crops or pedda panta.

Sowing and planting.—Experiments conducted at the Agricultural Research Station, Anakapalle, showed that the best yields were obtained when single seedlings were planted. The best spacing was three-fourths of a link either way. Seedling of 14 to 28 days of age could be planted without making any appreciable difference in the final yields.

Experiments on ragi irrigation were conducted in 1943–47 in the Central Farm, Coimbatore, and these indicated that the quantity of water required by a crop of 122 days duration varied from 23·3 to 33·9 acre inches of water. The irrigations were best given at weekly intervals at three acre-inches per irrigation.

Manuring.—As in the case of other crops like rice and sorghum, in ragi too, no marked difference was found in the effect of different forms of organic manures. Thus the difference in yields, after applying compost or farmyard manure, was not very definite, but both of them were better than no manure. A higher dose of 75 lb. of nitrogen per acre applied in the form of either of these organic manures was significantly superior in yield to 50 lb. of nitrogen per acre.

Pre-treatment.—When ragi seeds were soaked before sowing in a 10 per cent dilution of cow's urine, it was found that the yields of grain and straw were significantly improved.

Pests and diseases.—Ragi is relatively free from any major pests or diseases. The red hairy caterpillar (*Amsacta albistriga*) occasionally becomes a pest. The description and control measures of this as well as other pests of ragi are given in Chapter 22.

Among diseases may be mentioned a smut, and *Helmintho sporium* and occasionally *Piricularia* spp., a fuller account of which will be found in Chapter 23.

Harvesting and yields.—Being a crop that tillers profusely, the earheads in ragi do not ripen all at the same time and hence the harvest has to be done twice, and even thrice, in the case of irrigated crops. Only the fully ripe earheads are gathered at each harvest. These are cut and carted to the threshing floor where they are heaped for a few days to get " cured." before threshing. If the earheads get too dry, water is sprinkled to make them pliant. An experiment was carried out in the Millet Breeding Station at Coimbatore to see the difference in time and labour involved in threshing ragi earheads with and without this " curing ". It was found that cured earheads needed less time and labour to thresh out than fresh cut uncured earheads. But it was also noticed that the seeds obtained from such heaped heads had a poorer percentage of germination, so that this " curing " is not advisable for ragi that is required for seed purposes. The operation of threshing is done by beating the earheads with sticks when the quantity is large. The grain is trodden out by bullocks. The cleaning is done by throwing up the threshed produce against the wind to blow off the chaff. In Mysore and adjoining parts of Madras, a stone roller is also used sometimes for threshing ragi grain.

Yields.—The average yield from a rainfed crop is about 600 lb. per acre, ranging from 400 to 800 lb. and that from an irrigated crop from 1,000 to 2,000 lb. with an average of about 1,500 lb.

Storing.—Ragi grain is rarely used as food, when freshly harvested. It is invariably stored for some months before it is utilized. Storage is usually done in pits dug in high level areas where the bottom of the pit is dry. They are eight to ten feet deep and about fifteen feet wide at the bottom and are constructed with a vaulted

top leaving a manhole for getting in and out. Other methods are *pakka* masonry granaries, or receptacles made out of split bamboos or twisted straw or even earthenware pots. These traditional methods are now-a-days being replaced by jute bags. Ragi keeps well in storage and is not damaged by insect pests so readily as sorghum or bajra.

For use as seed, the earheads are hand-threshed with sticks, the grain well dried and stored in closed receptacles. Some farmers prefer to keep their seed material as earheads, without threshing. The viability is retained for over two years if properly stored.

Food value of ragi.—Ragi when prepared in the proper way is as good as any other cereal food. The analysis of ragi grain is given below (Akroyd 1938) :—

	PER CENT.		PER CENT.
Moisture	13·1	Iron	5·4 gms./ 100 gms.
Protein	7·1		
Fat	1·3	Calorific value per 100 gms. ..	345
Mineral matter	2·2	Carotine International units of vitamin A per 100 gms. ..	70
Fibre	Nil.		
Carbohydrate	76·3	Vitamin B_1	40
Calcium	0·33	Vitamin B_2	poor.
Phosphorus	0·27	Vitamin C	Nil.

Preparations made out of ragi are many and varied. The most important of them is *sankati* (Telugu) or *kali* (Tamil). The grain is cleaned and ground into flour either by hand or in a power mill and then cooked into a paste like consistency. *Ambali* or *koolu* is another preparation which is also fairly common. For this the flour is soaked in water and allowed to ferment for about 12 hours. Broken rice, sorghum or bajra flour is cooked in a separate vessel and when this is on the boil, the fermented ragi liquid is added, and the mixture well boiled and then removed from the fire.

Cakes of various types can also be made out of ragi flour, similar to rice '*Iddlies*' and '*Dosais*'.

THE ITALIAN MILLET (*Setaria italica*).

(Telugu—*Korralu*; Tamil—*Tenai*; Kannada—*Navane*; Malayalam—*Tena*; Hindustani—*Kangoone*.)

Production and importance.—Setaria is one of the minor food crops of dryland areas. It is cultivated in many parts of the world such as China, Japan, and Eastern Asia, South Africa, South-east Europe and in North America. In India, it occupies large areas in Bombay, and in Madras it is grown on 1·5 million acres with an annual output of two lakhs of tons of grain. Nearly three-fourths of the setaria in Madras is grown in the Ceded districts

comprising the four districts of Cuddapah, Kurnool, Bellary and Anantapur. The acreage in different districts is given below :—

District.	*Total area.*	*District.*	*Total area.*
	ACS.		ACS.
1 Bellary	481,000	14 Ramanathapuram ..	1,800
2 Kurnool	449,000	15 West Godavari ..	1,580
3 Anantapur	307,000	16 North Arcot	1,420
4 Cuddapah	103,000	17 Krishna	1,250
5 Guntur	82,900	18 Malabar	1,170
6 Nellore	32,700	19 Tiruchirappalli ..	720
7 Coimbatore	26,800	20 Chingleput	700
8 Salem	14,500	21 Tirunelveli	380
9 Visakhapatnam ..	10,700	22 The Nilgiris	220
10 Madurai	10,500	23 Tanjore	70
11 South Arcot	8,010		
12 East Godavari ..	4,800	Total ..	1,542,640
13 Chittoor	2,420		

The average annual production of grain of this millet in the State is estimated at 200,000 tons.

Climate, soils, etc.—Setaria can be grown on a wide variety of soils and at any time of the year, though it thrives best on good black or red loams, in areas of low to moderate rainfall of 15 to 30 inches per year. It is usually sown either pure or mixed with cotton in September on the black soils of the Ceded districts as a rainfed crop. Under irrigation it is grown during the hot weather from March to July.

Varietal introductions and trials.—The same method as described in rice and sorghum was adopted in the improvement of this millet also, a large number of varieties being gathered from various parts of the State and other places and grown at the Millets Breeding Station, carefully studied for all their morphological and economic features and selecting the best of them after testing for yielding capacity over a number of seasons. Similar work was done at the regional research stations to evolve high yielding strains that were suited to the respective tracts and regions. The strains that have been evolved in this manner and released for distribution to ryots are described below :—

Strain number.	*Season.*	*Remarks.*
	Agricultural Research Station, Guntur.	
G 1.	(1) Punasa—June—October (2) Pyru—September—January ..	Suitable for Guntur and Kurnool districts. Grain Yield 800 lb. Duration 80 to 95 days.
	Agricultural Research Station, Nandyal.	
N 1.	June to September (Punasa) September to December (Pyru) ..	Suitable for Kurnool and Cuddapah districts. Duration 90 days.
	Agricultural Research Station, Hagari.	
H 1	July—September to November—December ..	Suitable to light soils of Anantapur and Bellary districts.
H 2.	Do. ..	Suitable for heavy black soils of Bellary district.

Strain number.	*Season.*	*Remarks.*
	Millet Breeding Station, Coimbatore.	
CO 1.	March—July (Irrigated)— September—December (rainfed).	From *Mosu tenai* of Coimbatore. Duration 100 days. Suitable for Salem and Coimbatore districts. Yields 750 to 1,000 lb. of grain per acre.
CO 2.	March—July (Irrigated) ..	Duration 90 days. Suitable for Salem, Coimbatore and Madurai districts. Yields 800 to 2,000 lb. of grain per acre.
CO 3.	September—December	From *Perum tenai* of Coimbatore. Duration 100 days. A dryland variety suitable for Coimbatore. Yields 800 to 1,200 lb. of grain per acre.

Fundamental studies.—A brief account is given below of the genetic and other fundamental studies that were made on this millet at Coimbatore. Varieties of setaria vary much in their height, the tall plants proving a simple dominant to short plants. Six different classes of purple pigmentation are met with and the pigmented condition of the plant is dominant to the non-pigmented condition. The pigment is produced by one factor and it becomes intensified with the addition of another. The interactions of these two factors and other factors which determine the manner in which the pigmentation is manifested result in the diversity of pigmentation types found in the varieties of this millet. A primitive type of lax earhead was observed with fewer spikes, fewer spikelets and chronic sterility. It behaves as a monogenic recessive to the normal dense, economic type of earhead. All setarias have bristles. They fall into four groups: long, medium, short and dwarf. The dwarf bristle is the basic condition. It is due to one factor. Three other factors acting on this basic factor are responsible for the four different lengths. One of them determines the expression of the various bristle types. Occasionally an extra spikelet is borne at the tip of the bristle. When most of the bristles are tipped, it is designated full and is allelomorphic, to the 'nil' spikeletted condition. In some families this fully bristle-spikeletted condition behaves as a monogenic recessive to the 'nil' type while in others the dominance is incomplete. A study of anther colours showed that a brownish orange colour of the anther is dominant to white. Yellow anthers are dominant to white and recessive to brownish orange anthers. Six distinct grain colours have been noted and their differences studied and described in great detail. They are black, tawny buff, korra buff, sepia, red and tawny red. Three factors are responsible for these various combinations and their interaction produces the wealth of grain colours in this millet. After a

detailed study of various types of correlations and variations in 44 different varieties of setaria, it has been found that the least variable features in this millet are height of the plant, main earhead dimensions and mean weight of 500 grains.

Cytological work.—Chromosome numbers of a few of the wild relations of the cultivated species were determined. *S. italica* (cultivated)—2n = 18; *S. verticellata*—2n = 18; *S. glauca* —2n = 36; *S. intermedia*—2n = 36; and *S. palmifoliai*—2n = 54. Thus the genus has representatives of diploid, tetraploid and hexaploid species. Except the cultivated, the others are more or less perennial.

Agronomic experiments—Seeds and sowing, seed rate—Millet Breeding Station, Coimbatore.—To determine the optimum seed rate for tenai which will give the highest yield an experiment was conducted in 1948. The treatments were 2, 3, 4, 5, 6, 7 and 8 lb. of seed per acre. The yield data showed that differences between treatments were not significant.

Spacing.—To ascertain the optimum spacing required for tenai an experiment was laid out in 1948. The treatments were 1, 1½, 2, 2½ and 3 links space between rows. The results indicated that one link spacing was the best and was on a par with 1½ and 2½ links spacings, while three links spacing gave the lowest yield.

Manuring—Cattle manure v. *compost experiment—Hagari.*—Korra is found to respond better to cattle manure than to Indore compost. The application of manure to korra results in more pronounced residual effects during subsequent years than if the same manure was applied to sorghum. This 'crop effect' was evident on sorghum but not on cotton.

Pests and diseases.—No special mention is needed for these as the same pests and diseases as are found on sorghum, bajra and ragi, attack this millet also.

Harvesting, yields.—The earheads are either cut or nipped off when fully ripe and kept heaped upon the threshing floor for a few days before threshing which is carried out in the same manner as for other millets, by cattle threshing, or stone roller or beating with sticks. The straw, being thin and fine, is considered to be better as a cattle feed than bajra straw.

The yields, as in all these rainfed millets, are apt to be widely variable, ranging from 400 to 800 lb., under favourable conditions from a pure crop of rainfed setaria. Irrigated crops may yield up to 1,200 lb. of grain per acre.

Food value of setaria.—The grain has to be husked before it can be used. It is generally cooked like rice, either entire or broken or made into porridge. The composition is given below (Akroyd) :—

	PER CENT.		PER CENT.
Water	11·2	Fibre	8·0
Albuminoids	12·3	Ash	3·2
Carbohydrates ..	60·6		

THE KODO MILLET (*Paspalum scrobiculatum*).

(Telugu—*Arika*; Tamil—*Varagu*; Kannada—*Haraka*; Hindustani—*Kodra*.)

Production and importance.—Arika is the coarsest among the foodgrains. Though remarkably drought-resistant, it is a crop of minor importance. In Madras State it occupies an area of one million acres. The normal area under this crop in different districts of the State is given below :—

District.	*Total area.*	*District.*	*Total area.*
	ACS.		ACS.
1 Tiruchirappalli ..	140,000	14 Chittoor	19,000
2 South Arcot	135,000	15 Tirunelveli	10,800
3 Nellore	125,000	16 Visakhapatnam ..	9,800
4 Kurnool	93,200	17 Coimbatore ..	6,810
5 Ramanathapuram ..	84,000	18 Krishna	3,200
6 Salem	71,000	19 East Godavari ..	3,080
7 North Arcot	67,800	20 West Godavari .	2,120
8 Madurai	67,700	21 Bellary	890
9 Anantapur	37,800	22 Malabar	150
10 Cuddapah	32,400		
11 Tanjore	31,800	Total ..	987,250
12 Chingleput	26,600		
13 Guntur	19,100		

Climate, soil, etc.—The crop is usually relegated to gravelly and stony soils, light upland soils, and all poor soils in general. In spite of adverse conditions the crop comes up even on these soils and yields a small return. It occupies the ground for over six months, a period longer than any other millet.

The seed is sown broadcast after a good soaking rain at the commencement of the south-west monsoon. The seed rate is about 20 lb. per acre. After sowing no further care is taken of the crop.

Fundamental studies.—A preliminary study of this millet has shown that it is slow in germination, the first signs of germination being seen only on the fifth day. The seedlings are generally unpigmented, though adult plant develops purple pigment later. In the adult plant the nodes may be swollen or not according to varieties. The number of tillers varies from five to eighteen according to varieties. The leaves are dark green usually and the size of the leaf varies with varieties, and a considerable range in their length has been noted resulting in differential habits. Purple pigmentation has been observed particularly in the adult plant in most of the varieties. In the seedlings this manifests itself as a purple wash. At a later stage, the nodal bands become purple. With increased growth, the other parts of the plant also get this wash of purple. The optimum manifestation of the purple pigment is from the flowering to milk stage of the grain. Looked at *en masse*, the field crop has a characteristic violet look. The depth of the purple pigmentation varies according to varieties. The panicle is usually borne at the fourth node and takes about a week

to emerge. In this millet, the panicles never emerge fully. A number of variations have been met with in the nature of branching of the panicle. Single seeded and double seeded spikelets have been described. " Arika " is highly cleistogamous. Natural crossing is almost completely absent. Manipulation of the spikelet for artificial pollination irretrievably damage it and all attempts at emasculation and artificial pollination have been failures. In this millet, the seed setting is more or less completely dependent on the weather conditions. False polyembryony has been noticed. This is due to the branching of the mesocotyl into two at a very early stage in the development. The wild Paspalum (*Paspalum sanguinale*) scores over *Paspalum scrobiculatum* in possessing a number of valuable characters such as more herbage, free earheads, greater drought resistance, large numbers of seeds per head and absence of sterility. A cross with this wild ally is indicated as a potential source of improving the *Kodo* millet, if the difficulties in the manipulation of the close and delicate cleistogamous flowers could be overcome.

Economic work.—A large number of samples of *varagu* seed was collected from districts and yields studied. Out of the 71 samples tested 58 single plant selections were taken and of these, only one type PS 1 was found to be the best and kept as a strain.

Pests and diseases.—The plant is very hardy and relatively free from pests and diseases, except for occasional trouble from white-ants attacking the base of the clumps in the wake of a long dry period.

Food value.—The composition of the grain is given below (Akroyd) :—

	PER CENT.		PER CENT.
Water	12·8	Fats	1·4
Carbohydrates	65·6	Fibre	0·9
Albuminoids	8·3	Ash	2·9

The grain is sometimes recommended for diabetic persons as a substitute for rice.

In certain localities and stagnant areas of Tanjore and Tiruchirappalli districts, it has been reported that Arika grains proved poisonous. This requires further study and investigation.

Proso or Hog Millet or Common Millet (*Panicum miliaceum*).

(Telugu—*Variga* ; Tamil—*Panivaragu* ; Kannada—*Baragu* ; Hindustani—*Barri*.)

Production and importance.—Variga is another minor cereal which is quick growing and highly drought-resistant. In the State it occupies an area of about half a million acres. There are two main zones for this millet, namely, the Guntur zone comprising of Krishna, Guntur and Nellore districts and Madurai zone consisting of the districts of Madurai, Ramanathapuram and Tirunelveli. In the northern districts it is a dry crop while in the southern districts it is an irrigated crop.

Cultivation practices.—This crop is grown both under rainfed and under irrigated conditions. It is usually grown on the poorer types of soils. In dry lands, seed is sown by drills in rows, nine inches apart and covered with a brush harrow. The seed rate is usually 8 to 10 lb. per acre. The seed is also sometimes sown broadcast when the sowings have to be hurried through.

The straw is considered a good fodder. The yields may range from 400 to 500 lb. of grain per acre. Under irrigated conditions twice these yields may be obtained.

Fundamental studies.—Pollination studies were made on this crop with a view to effect successful hybridization. The flowering in this crop also proceeds from top downwards. It takes ten days for the panicles to complete flowering. The flowers open between 10 a.m. and 12 noon. This millet is, as a rule, self-fertilized, though a very small amount of natural crossing does occur. The very short interval between the opening of the flower and dehiscence of the anther makes artificial crossing difficult. It has been possible to prolong this interval by proper manipulation of individual mature flowers one hour before the usual opening time. Rare instances have been noted of the third glume bearing flowers and of the existence of poorly-formed double grains, the doubling being brought about by the addition of an extra pair of fertile glumes and palea. There are two types of purple pigmentation in the plant, purple and light purple. In the absence of the P. factor for purple pigmentation, the plants are completely green (pp.) *P* is a monogenic dominant to *p*. An intensification factor I is a monogenic dominant to *i*. An intensification factor I is responsible for the difference between purple and light purple types. Purple (PP. II) is a monogenic dominant to light purple. A dihybrid ratio of 9 : 3 : 4 has been obtained in segregations between purple, light purple and green plants. The characteristic hairiness in the common varieties of this millet is governed by the operation of three independent factors, any one of which produces hairiness. The hairy type is the result of the absence of all the three factors H.1, H.2 and H.3. They are also cumulative in their effect. The common grain colours in this millet are dark olive grey and buff yellow. A monogenic dominant factor O makes buff yellow into dark olive grey. A second factor L lightens these two colours and produces light olive grey and light buff yellow types. A third factor I inhibits the expression of colour on the glume making it ivory white. Factor I is a monogenic dominant to its absence. The two grain colours, ivory grey and ivory yellow, are the results of the operation of this I factor. Reddish orange, a third whole colour, on the other hand, is a monogenic recessive to buff yellow. In this chain, dominant factor Bf suppresses the red in reddish orange, producing buff yellow.

Economic work.—Out of the 292 samples collected from various districts and studied, 392 single plant selections were found to be promising. These were tested for yield and one of them PV 86

has been found to be the best economic type. Another selection PV 14 is slightly longer in duration and yields more heavily than PV 36.

The crop is not subject to any serious pests or diseases. A smut and a rust are reported which, however, are of minor importance.

The grain is eaten cooked like rice or ground into flour and eaten as pudding. The chemical composition of the grain is as follows (Akroyd) :—

	PER CENT.		PER CENT.
Water	11·9	Carbohydrate	68·9
Albuminoids	12·5	Crude fibre	2·2
Fats	1·1	Ash	3·4

SAMAI OR THE LITTLE MILLET (*Panicum miliare*).

(Telugu—*Sama* ; Tamil—*Samai* ; Kannada—*Sane* ; Malayalam—*Sama* ; Hindustani—*Shavan*.)

Samai is grown only to a limited extent in the different States of India and figures are not available regarding the acreage of this crop in India. In Madras, the normal area under this millet is 589,940 acres, the chief centres being Salem, Anantapur and Coimbatore. It is a crop that can be grown at higher elevations, up to 7,000 feet. The duration is usually two and a half to three months but some of the hill varieties grown in the Agency tracts of the Northern Circars are longer in duration and take about five months from sowing to harvest.

Studies on the anthesis of this millet have shown that the spikelets open between 9 a.m. and 12 noon at Coimbatore. Self-pollination is the rule. Though the spikelets are very small, artificial crossing by emasculation of the anthers and pollination by another parent can be accomplished with a fair amount of success. Very good results can also be obtained by contact crosses.

Two types of purple pigmentation are known. These are conditioned by two factors in the absence of which the plant is green throughout. In segregations, these three groups, purple, medium purple and green, are found in the ratio of 9 : 3 : 4. In grain colours too, three groups, namely, very light olive-brown, light oblive-brown and oblive-brown, occur, these being determined by the inter-action of two additive factors which are inhibitory in effect on olive-brown grain. Albinism has also been noted in this millet in the seeding stages. Duplicate factors, C_1 and C_2 were found responsible for the development of the green colour.

On the economic aspect, 13 samples were collected from various places out of which 268 single plant selections were taken for study and yield tests. From these one selection PM 2 was chosen as the best and the most economic type. Bulk selections were also made at the Nanjanad Agricultural Research Station and high-yielding selections have been retained.

BARNYARD MILLET (*Echinochloa colona var. frumentacea*).

(Telugu—*Oodalu or Barigalu*; Tamil—*Kudiravali*.)

This is one of the least important millets and except in certain limited areas, its importance both in Madras and in other Indian States is very little. Its main advantage is that it serves as a famine crop as it is able to grow even on very poor soils with hardly any attention.

Fundamental studies made at Coimbatore have shown the existence of three pigmentation types in descending order of purple pigmentation in addition to a green (non-pigmented) type. These show in inheritance a two factor difference. The panicle shapes are of three types, open, semi-compact and compact. These are considered to be due to the differences in the density of spikelets and the lengths of the spikes. The genetic relationships of these three types have not yet been fully studied. A type of male sterility, recessive to the normal fertile condition, has been observed. Albino striping was also noted and its progeny gave seedlings with green and pale green colouration in varying proportions.

Twenty-seven samples were gathered from various sources and studied and 381 promising selections taken. These were tested for yields and one of them PC 49 has been chosen as the best and most economic type in this millet.

CHAPTER 5.

PULSES.

Varietal collections—Introduction and trials—Evolution of strains—Redgram, blackgram, greengram, Bengalgram, horsegram, lab-lab, cowpea, soyabean—List of strains evolved—Agronomic experiments—Area, production, imports and exports of pulses in Madras.

Common name.	*Botanical and vernacular names.*
1 Redgram	*Cajanus cajan*, Millsp. Tamil—*Tuvarai.* Telugu—*Kandulu.* Kannada—*Togare.* Malayalam—*Tuvara.*
2 Blackgram	*Phaseolus mungo L.* Tamil—*Ulundu.* Telugu—*Uddulu.* Kannada—*Udid.* Malayalam—*Uzhunnu.*
3 Greengram	*Phaseolus aurens L.* Tamil—*Pasi payaru.* Telugu—*Pacha pesalu.* Kannada—*Hesara.* Malayalam—*Cherupayaru.*
4 Bengalgram	*Cicer arietinum L.* Tamil—*Kadalai.* Telugu—*Sanagalu.* Kannada—*Kadale.* Malayalam— *Kadalakka.*
5 Horsegram	*Dolichos biflorus L.* Tamil—*Kollu.* Telugu—*Ulavalu.* Kannada—*Huruli.* Malayalam—*Muthira.*
6 Cowpea	*Vigna unguiculata*, Walp. Tamil—*Karamani.* Telugu—*Alasandalu.* Kannada—*Alsande.* Malayalam—*Vellappayaru.*

Common name.	*Botanical and vernacular names.*
7 Lablab	*Dolichos lab-lab L.*
	Tamil—*Mochai, Avarai.*
	Telugu—*Anumulu.*
	Kannada—*Avare.*
	Malayalam—*Avara.*
8 Soybean	*Glycine max*, Merr.

Production and importance.—Among the various food crops of the tropics, pulses constitute an important group, as they form the main source of proteins in a vegetarian diet. As such, the pulse crops occupy a very important place in Indian agriculture and in Madras, a predominantly rice-consuming State, their importance is all the greater. The seeds inside the pods yield the pulse for human consumption; while the by-products like the husk and broken seeds make an excellent feed for cattle.

The term pulses includes a number of leguminous crops such as Redgram (*Cajanus cajan*), Bengalgram (*Cicer arietinum*) Blackgram (*Phaseolus mungo*), Greengram (*Phaseolus aurens*), Horsegram (*Dolichos biflorus*), Cowpea (*Vigna unguiculata*), Field and Garden Beans (*Dolichos lab-lab*). Soyabean (*Glycine max*) is another legume which is a very important pulse crop in other countries like China and Japan, but it has only a minor status in Madras. Groundnut, though a legume, is classed among the oilseeds and is not included among the pulses.

For an annual consumption of 583,450 tons of pulses in Madras, the production is only 251,200 tons or 43·0 per cent, leaving a deficit of 332,250 tons to be made up by imports (Statement No. 1). In other words, more than half the quantity of pulses that is needed for Madras has to be imported from other Indian States at a heavy cost. Madras imports Bengalgram from the Punjab, and redgram from Bombay, Hyderabad and Madhya Pradesh. The available figures for imports and exports of various pulses in Madras are given in Statement No. 2 and would serve to show the heavy cost that is incurred in making these imports every year.

In spite of its importance, however, it was not until 1943, that a scheme of improvement of pulse crops was started under the joint auspices of the Madras Government and the Indian Council of Agricultural Research. A separate section was opened under the charge of a whole-time Pulses Specialist, with Coimbatore as the main centre and two regional substations at Salem and at Vizianagram, for studying the pulse crops in the southern and northern regions of the State. Prior to the opening of a separate section in 1943, a certain amount of work had been carried out on redgram

and Bengalgram in Cotton Section and on cowpea and lab-lab in the Millets Section as a side lines of study. All the material gathered during these studies was taken over when the Pulses Section was formed as a separate unit in 1943.

Climate, soil, irrigation and their influence on the crop.—Pulses can thrive on a wide range of soils and altitude up to 2,500 feet above sea level. In Madras, pulses are grown extensively in the central districts and in the districts of the eastern coast. The hilly Nilgiris and the coastal districts of Malabar and South Kanara on the west coast have only very limited areas under pulses, chiefly because pulses cannot stand heavy rains, nor can they survive any prolonged drought. Light showers received in intervals of two to three weeks during the growing period are what the pulses need for optimum yields. Thus redgram is sown with the first rains of the south-west monsoon, while Bengalgram is dibbled into the soil in the waning phase of the north-east monsoon. The other pulses are also sown in the period in between these two monsoons when the rains are not too heavy. Horsegram is sown in September-October, though the fields may often be kept fallow till then. With regard to temperature, pulses grow well between 70° to 95° F., a range which prevails in the central districts of Madras during the months of October to February.

Generally pulses are grown only as rainfed crops, with the aid of the monsoon rains, by adjusting the time of sowing to get the maximum benefit from these rains. Occasionally, however, and in limited areas, pulses are grown with the help of irrigation. Such crops are chiefly redgram and cowpea.

Soils.—In South India, pulses are grown on a wide variety of soils, ranging from the coarse gravels of hill slopes to the moist and heavy soils of the plains and deltas. On the lighter soils, redgram is sown with the onset of the south-west monsoon, while on heavy black soils of Kurnool, the sowing of redgram is delayed up to the end of July. In Madurai and Ramanathapuram districts. redgram is sown in heavy soils as late as October, after getting rains from the north-east monsoon, because the south-west monsoon is generally too feeble in these districts to support a pulse crop like redgram. Another reason is that early sowing in heavy soils is likely to cause wilt owing to water stagnation. In the deltaic tracts there is also a practice of utilizing the wetland bunds, for raising redgram and blackgram, by dibbling the seeds on the bunds, after planting rice.

Varietal collection, introduction and trials.—In keeping with the extensive area and the wide variations in climate and soils that exist in Madras, a large number of varieties also exist in each of the different pulse crops. In redgram for instance, varieties range in duration from four and a half months as in the Tenkasi variety up to eight months in some of the varieties grown in Visakhapatnam. Between these two extremes, there

is the normal six month's variety grown in the central districts of the State, especially in Tiruppathur in North Arcot district. On the basis of growth habit, colour and size of seed, numerous varieties are distinguished in redgram. Likewise, in the other pulses too, there are wide variations in duration, size and colour of seeds. For example, the blackgram that is suitable for sowing in August-September as a dryland crop takes four months to mature as against 90 days for the wetland type that is raised in the deltas, after the harvest of rice in February. In greengram too, there are two distinct types, one grown on drylands and the other in wetlands. Bengalgram also shows wide variations in duration, size of seed, colour and wrinkling. In horsegram there is a buff-coloured type and a black one, the former being longer in duration than the latter. Among cowpeas, variations are found in size of seed, colour, duration and plant habit.

Evolution of strains—(a) By selection.—An outline is given in the following pages of the progress made so far in the Pulses Section in evolving high yielding strains in each of the different pulses, redgram, blackgram, greengram, bengalgram, horsegram, lab-lab and soyabeans. Selection work was carried out at three centres, namely, Coimbatore, Salem and Vizianagaram, since 1944. The general method was to collect a large number of samples of each pulse in and around each centre of work and test them over a number of seasons, for their yielding capacity and other desirable features. To begin with, a number of samples of each kind of pulse are collected from various localities in different districts, such that the number in each would be not less than twenty-five. These samples are then grown for yield in ' Lattice design ' trials with four replications. When the crop is mature, each sample is studied in detail for all plant characters including yields. Before harvest, however, single plants with the most desirable economic traits, are selected individually from the four repetitions of all the samples. The yield figures are then analysed statistically. All the plants selected from the highest yielding sample, together with some of the heavy yielding plants from other samples numbering, say, over a hundred selections, might be retained for further tests. In the second year, these single plant progenies are grown along with local bulk as control in the same ' Lattice design ' with four replications, to know the relative merits in yield of the different families. After harvest, the yield figures of the cultures are subjected to statistical scrutiny and all cultures, that are significantly better than controls, are passed on for further tests. In the third year, the yield trials get repeated in the same ' Lattice design ' with a reduced number of cultures. By the fourth year, the cultures might be brought down to twenty or less, when the trials are laid out in two series, in randomized replicated plots with six to eight repetitions. From the results obtained, the number of cultures is further reduced. In the fifth year, the cultures enter the final stage of trials, with less than

Redgram.

Plate 23.—Blackgram.

half a dozen in number and the trials are laid out in randomized blocks with eight repetitions. In the sixth year, trials are repeated on the research station and one or two top-ranking cultures sent for trial in the districts under cultivators' conditions. These trials are repeated in the seventh year also and the highest yielding culture, whose performance had been consistent for three to four years, is released for general cultivation as a strain with a station number. It should be mentioned here that, as all the pulses are grown under rainfed conditions in drylands, the number of years needed for the evolution of a strain is very often, more, due to unfavourable seasons occurring frequently.

So far improvement has been sought to be effected chiefly by selection of superior types from among the varietal collections available in each of the different pulse crops. Hybridization, for widening the scope of selection and for combining different desirable characters, will be taken up as the next stage in the improvement of pulses.

Redgram—(*Cajanus cajan*) (*Plate* 23).—Forty-seven samples were collected from all over the State and sown at Coimbatore in 1944, out of which 140 single plant selections were chosen as possessing desirable characters and sown in 1945, in row yield trials. From these trials, 21 cultures that gave better yields than the local variety and had also other desirable features such as a good colour and freedom from disease, were retained for further trials. In 1946, these were grown in replicated yield trials but the differences in yield were not statistically significant. In the next year, 1947, these trials were repeated under irrigated conditions, as the south-west monsoon proved a failure, but even under irrigation it was not found possible to secure normal growth and yields, so that the trial had to be repeated once again in 1948. Eight cultures gave higher yields than the culture No. 1723 that was used as the control. In 1949, these eight selections were again tested in yield trials, but the differences were not statistically significant.

In addition to these eight selections, there are 142 cultures gathered from Coimbatore, Tanjore, Kurnool, Bellary and Anantapur that are under study at present. Thirty-four wilt-resistant cultures of redgram from Northern India were also under test for three seasons 1946–48, but none of them proved quite suitable for South Indian conditions.

At the Salem substation, 23 samples collected from North Arcot, Salem and neighbouring districts were grown in 1944, and 119 single plants with desirable characters were selected and sown in row yield trials in 1945. In 1946, five cultures that had given better yields than the local in the previous year were tested in yield trials, along with five more that were on a par with the local in 1945. Six of these ten were better than the local type that was used as the control and so they were again tested in 1947, in replicated yield trials, when four cultures were found to be

distinctly superior to the control. These four were tried again in 1948 at Dharmapuri, 42 miles away from Salem, but owing to an adverse season, no reliable results could be secured. However, one selection, No. 37, out of these four, was found to give consistently high yields and was tried out in ryots' fields over 22 centres in seven districts. In most of the centres this selection gave higher yields than the local types. It is proposed, therefore, to release this selection for general distribution to ryots in the coming year 1950. (Plate 24 and 25.)

At the Vizianagaram substation, 23 samples collected from the northern districts of the State, were grown, along with the local sample in 1944 and 100 single plants were selected and tested in row yield trials in 1945. Nineteen cultures gave higher yields than the control and these were tested in replicated yield trials in 1946. Two cultures Nos. 97 and 98 showed a significant superiority in yield over the control in that year as well as in the two subsequent seasons, in 1947 and 1948. They were, therefore, tried out in ryots' fields in 1949 over seven centres in four districts but due to an unfavourable season that year, no reliable results could be secured.

Blackgram—(Phaseolus mungo) (Plate 23).—At Coimbatore, 49 samples consisting of 32 dryland types and 17 from wetland areas were collected from various places in the State and sown as a rainfed crop in 1944 for detailed study. It was noted that the dryland varieties were in general more vigorous and better in yield than wetland varieties, but had the quality of a long period of pod setting and ripening. Wetland types on the other hand. were short and erect in habit, with early flowering and uniform ripening of pods. Out of the 49 district samples, 190 desirable single plants were selected for further trials in 1946 but due to the adverse seasons in 1946 and 1947 the progress of work was considerably hampered. However, 120 cultures were sown in August 1948 in yield trials and five cultures were found to give higher yields than the control. These were tried again in 1949 July, but as the south-west monsoon was a failure, they had to be repeated in October with the break of the north-east monsoon. It was noted that the crop grows well with late sowings in October. Two cultures Nos. 212 and 216, were found to be significantly better than the local variety that was used as the control.

At Vizianagaram sub-station, 25 samples, made up of eight dryland types and 17 from wetlands, were grown on drylands in the main season of 1944. The wetland types did not flower at all. From the dryland types, 100 single plants were selected and put under yield trials in 1945. Fifteen cultures were better than the control in yield and these were tested again in 1946, 1947 and 1948 when one culture No. 189 was found to give consistently higher yields than the control. This culture will, therefore, be shortly released as an improved strain for the Vizianagaram zone.

Plate 24.—Bulk crops of improved strains.
Culture 37 (Redgram).

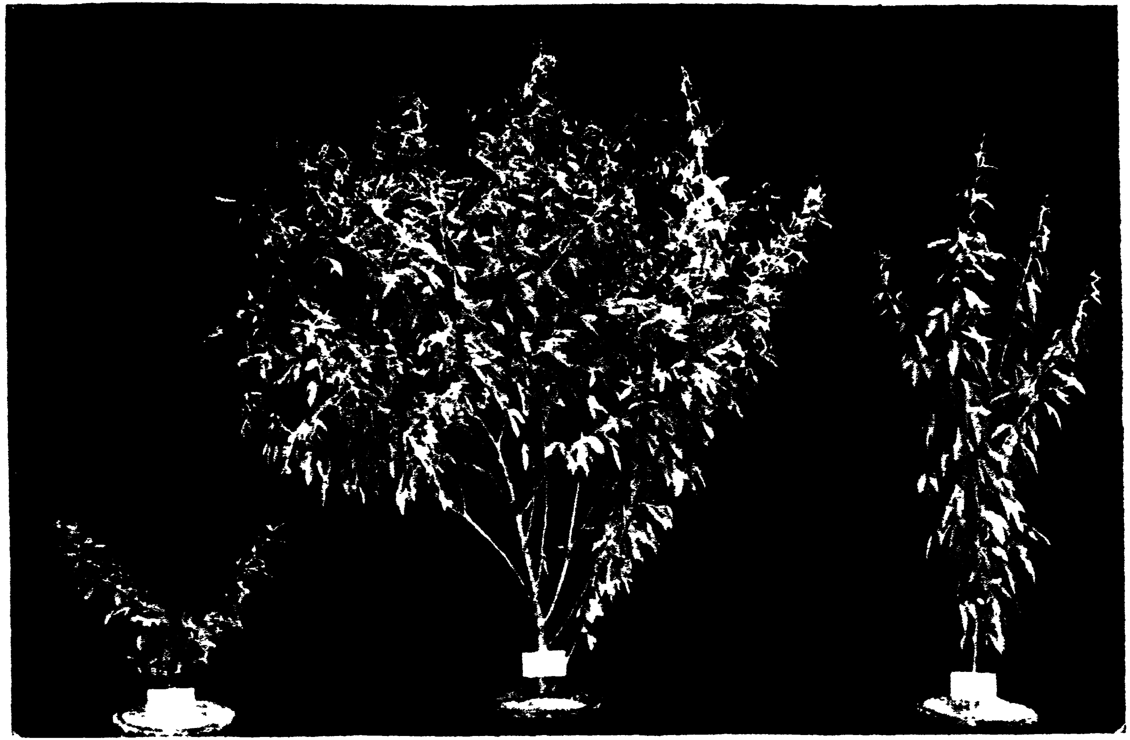


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Plate 25.—Variations in growth of redgram.

Tenkasi Variety. *Culture 37.* *Hill Variety.*

In order to evolve a strain of blackgram, suitable for growing in the wetlands of the Circars as an after-rice crop, 263 single plants were selected from district samples grown at the Agricultural Research Station, Samalkota during the year 1947. In 1948, these were grown again as an after-paddy crop in November for multiplying the seed. As a result of the observations made on these, regarding growth, flowering and duration, 23 desirable cultures were retained for further tests and put under yield trials in 1949. All of them gave higher yields than the local variety (control), with one culture, No. 265, standing out as the best.

Greengram (*Phaseolus aureus*).—At Coimbatore, fifty dryland types and fifty wetland types of greengram, gathered from various districts, were sown for study in 1944. As in the case of blackgram, here too, the dryland samples proved better than the wetland types when sown in the main season (July–August) under rainfed conditions. Two hundred and ninety single plants were selected from the high-yielding samples and sown in 1945 for multiplying the seed. In 1946, 161 of the best of these were sown in yield trials but the crop failed due to an adverse season, so that the reserve seed material in these selections had to be multiplied in 1947 at the Agricultural Research Station, Tirurkuppam, before a regular replicated yield trial could be laid out in 1948. One culture, No. 62, was distinctly better than the control (local variety) and two others No. 53 and No. 148 were as good as the control in yield. These have been kept for further tests, before the best of them is released as an improved strain. It was also noted that culture No. 62 was able to grow well and give heavy yields even when sown late in October with the aid of the north-east monsoon rains.

At Vizianagaram, 36 samples made up of nine dryland and 27 wetland types were sown on drylands in the early season under rainfed conditions in 1944. No difference was noticeable in growth between wetland and dryland types of greengram at this centre. From the high yielding samples, 100 single plants were selected and put under yield trials in 1945. Four cultures gave significantly higher yields than the local bulk. In 1946, these four along with another four cultures that were equal to the control in the previous season, were tested for yield in randomised replicated plots. One culture No. 127 was significantly better than the control. The next year the same eight cultures were again tested in a similar trial but none of them was significantly superior to the control. In 1948, the trial was repeated a third time, when No. 127 again proved better than the local by 42 per cent. Similar trials made at the Agricultural Research Station, Samalkota, resulted in the isolation of culture No. 188, as the highest yielder under wetland conditions as an after-paddy crop.

Bengalgram (*Cicer arietinum*).—Twenty-two samples were grown in 1943 at Coimbatore and 120 single plants were selected and sown in 1944 in trial plots but the crop failed due to excessive rains. Fresh collections were accordingly made in the next year

and studied in subsequent seasons, and by 1949, one culture No. 94, was picked out as a promising high yielding selection that was significantly better than the control for two successive seasons.

Two improved types, NP 2. from Delhi and G 24. from East Punjab were tested at Coimbatore but proved too long in duration to suit South Indian conditions.

Horsegram (Dolichos biflorus).—Here again, adverse seasons hampered the progress of work at Coimbatore considerably, but in spite of occassional crop failures, it has been possible to isolate one culture No. 35 as significantly superior to the control, a pre-existing selection No. D.B. 7. Twenty cultures are still on hand for further study and yield trials.

At the sub-station at Salem beginning with 35 district samples grown in 1943, a number of selections were taken and tested under yield trials in subsequent years, with the result that by 1947, four cultures have been found to give significantly higher yields than the control. Trials are in progress to pick out the best of these.

At Vizianagaram, 25 samples were collected and grown in 1943, 100 single plants selected and tested for yield in 1944. Six cultures that gave significantly better yields than control were carried forward for further trials. After a number of trials with these and other selections in the intervening years, two cultures No. 93 (black seeded) and No. 76 (buff-seed) were picked out as the best two in 1948 and 1949. These two cultures are now under test in ryots' fields, before being released as improved strains.

Field lablab.—Eleven cultures of field lablab were taken over from the Millets Specialist who had carried out the preliminary work on this pulse, and grown under replicated yield trials in 1946, 1947 and 1948 at Coimbatore. Culture No. 1458 was found to be better in yield than the control D.L. 173. In addition to these, 480 single plant selections are on hand for further study and isolation of a high yielding strain. (Plate 26.)

At Salem too, similar trials were conducted with samples collected from North Arcot and neighbouring districts and four cultures that appear to be promising have been retained for further tests.

Vegetable lab-lab.—A large number of samples of the kitchen garden variety of lablab were collected and grown, out of which 22 cultures were isolated after careful tests for yield and other desirable characters such as early fruiting, pod shape, size and colour. Out of these, five have been selected as the best for general distribution. They are D.L. 692, 250, 259, 269 and D.L. 389. (Plate 27.)

Cowpea (Vigna unguiculata).—In 1944, 33 district samples were grown at Coimbatore and after detailed study, 140 desirable single plants were selected and their seed multiplied during the next year. In 1946, 11 of these were tested for their yielding capacity against a pre-existing strain, C. 57 that had been evolved

Plate 26.—Field lab-lab. P. 191

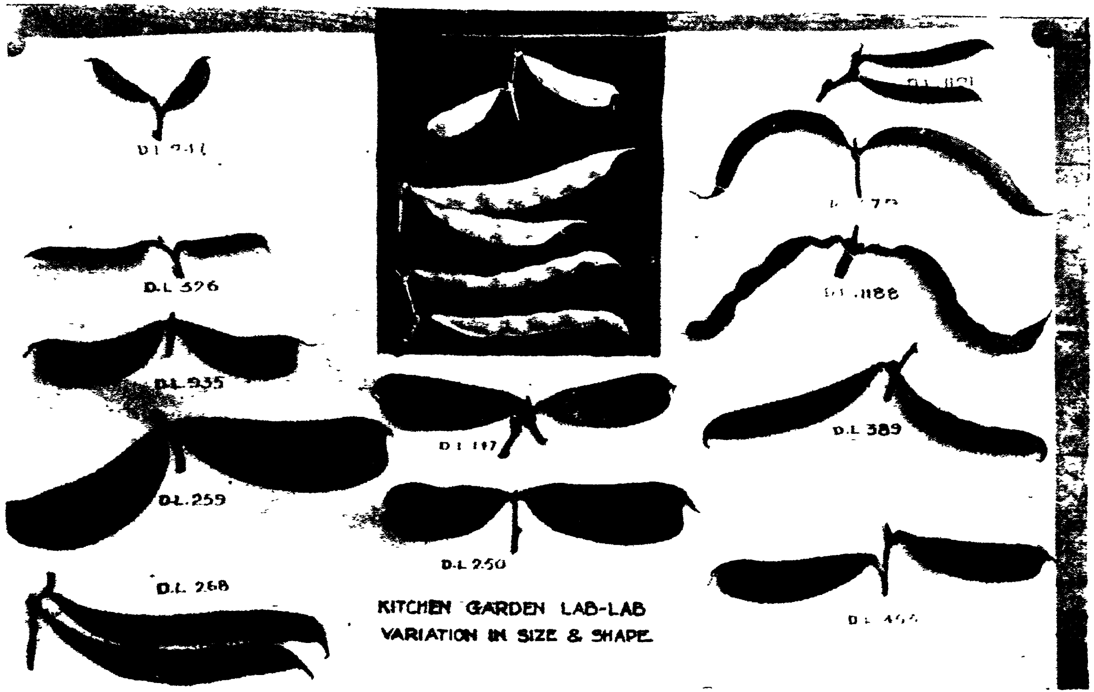

Plate 27.—Variation in size and shape of lab-lab.

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in the Millets Section. These trials were continued in subsequent years and by 1949, resulted in the isolation of three cultures that were as good as the existing strain C 57. Fresh samples have been collected again in 1948 from various districts and are now being tested for isolating a strain better than C 57.

Soyabean (*Glycine max*).—Soyabeans form one of the most important legume foods of the Mongoloid races. China, Manchuria, Korea and Japan are the chief countries of production and export of this pulse crop. The seed is very rich in proteins, fat and vitamins, besides being a good source of calcium and phosphorus. The starch content is very low. Soyabean is used in a variety of ways by the Chinese and Japanese. Soyabean meal and cake serve as an excellent feed for cattle, while the plants themselves form very good fodder.

Attempts to introduce this pulse crop to Madras were made at various times, the first trial being made in 1915 by Mr. R. C. Wood, who was then the Principal of the Agricultural College at Coimbatore. A number of other attempts were also made in several Research Stations between 1930 and 1938. It was found from these trials that a number of factors militated against its popularisation. For example, the plants were very badly attacked by numerous insect pests especially in Tanjore and other southern districts. When grown as a field crop in the Northern deltas, during June to November, the plants could not stand water stagnation, unless the fields were laid out with raised beds with deep trenches for free drainage. Since no farmer in the deltas would give up his rice crop in favour of other crops, soyabean cultivation in rice fields was found impracticable. It could, however, be grown successfully on the bunds of rice fields, since water logging is avoided thereby.

In spite of all the attempts that have been made so far, the fact remains that soyabean has failed to become popular in Madras, chiefly for the reason that people were not able to develop a taste for its peculiar flavour which is so much esteemed by the Chinese and Japanese. Soyabean was also found to be less easy to cook and digest than the common Indian pulses, like redgram or bengalgram.

(*b*) *Evolution of strains by hybridisation*.—As mentioned earlier, systematic hybridisation has not yet been taken up in the pulses section; however, three strains have been evolved in redgram, bengalgram, and lablab, by isolation from three different crosses.

In redgram a North Indian *Arhar* type was crossed with a local variety and an improved culture No. 2900 has been evolved with bolder seeds and 13 per cent higher yield than the local type. The acre yields range from 800 to 1,000 pounds, according to the season, and good reports have been received about its adaptability to varied soil and seasonal condition in the Ceded Districts, Guntur and the southern districts.

In bengalgram, two types T 8 and No. 493 were crossed and an improved culture No. 2965, with an attractive light brown colour, a bold and round shape of seed has been isolated. It yields up to 500 pounds per acre on the average and is now under distribution.

Lablab.—A number of crosses had been made in 1938–42 in the Millets Breeding Station, between the field lablab and the garden lablab, with the object of combining the stringless character of the garden variety with the profuse-bearing of the field lablab. From these crosses one promising selection, No. 1428 has been isolated and is expected to be available for distribution in the near future.

(c) *List of improved strains in pulses*.—The details of these are furnished in Statement No. 11.

5. *Agronomic studies on pulses*.—It is a well-known fact that pulse crops can fix atmospheric nitrogen in the soil, through the agency of the bacteria in their root nodules and are thus able to enrich the soil in course of time. Definite information is, however, lacking regarding the nature and degree of this soil enrichment in relation to the major pulse crops grown in Madras, the optimum type of association between specific pulses and cereal crops like sorghum or bajra or between a pulse crop and cotton. Definite data are also lacking regarding the degree to which different crops are benefited by growing a previous crop of pulses. A number of trials were, therefore, carried out in various research stations to gather information on these aspects.

At Coimbatore, trials were conducted during 1933 to 1936, by growing cotton both under irrigated and rainfed conditions, following a cereal like sorghum and various other pulse crops. There was no increase in yield when cotton, under irrigated conditions, followed a pulse crop, compared to cotton after sorghum, but under rainfed conditions, cotton after cowpeas gave significantly higher yields than after sorghum, the yields showing a 10 to 12 per cent increase. Experiments were also conducted at the Agricultural Research Station, Koilpatti (Tinnevelly district) between 1927 and 1936, and these experiments indicated that cotton yields were better after pulses than after cereals like sorghum or *bajra*, the best being cotton after horsegram, At Nandyal, in Kurnool district, cotton gave higher yields after a previous crop of *pillipesara (Phaseolus trilobus)* in two out of three trials.

With regard to mixtures of pulses with other crops a mixture of sorghum with redgram, greengram or soyabean in the proportions of 1 : 1 or 3 : 1 was good under irrigated conditions at Coimbatore (Statement No. 6). For rainfed crops on black soils, the results were in favour of equal proportions of sorghum-*pillipesara* or sorghum-lablab: for horsegram and cowpea, the ratio should be three of pulse to one of cereal (Statement No. 7). In red soils under rainfed conditions, the optimum proportions were 1 : 1 or 3 : 1 of pulses to sorghum.

Plate 28.—Mixed cropping experiment.

Varagu and redgram. *Sorghum and redgram.*

A similar set of experiments carried out at Coimbatore from 1946 to 1948, indicated that horsegram or blackgram when sown as a mixture with cotton gave better returns than the respective pure crops. In the case of greengram, however, the pure crop was found to be better than the mixture from a monetary point of view.

At Salem, an experiment was started in 1946–47 to study the economics of growing redgram by itself and mixed with other crops like sorghum, *samai*, *varagu*, or groundnut. It was seen that a pure crop of spreading groundnut or a mixture of groundnut and redgram gave the best monetary returns per acre, with no appreciable difference between the two treatments.

At Vizianagaram too, a similar experiment was laid out in 1946, with fifteen treatments and it was found that a mixture of redgram and *ragi* followed by horsegram gave the highest monetary return per acre. Along with these trials, the Agricultural Chemist started experiments at Salem and Vizianagaram on the effects of associated growth of cereals and pulses, from 1946 to 1949, and the results indicated that a mixture of equal proportions of a cereal and pulse crop was the best combination.

Zonal performance of pulses.—Varieties of pulses that are commonly grown in one region are seldom suitable for other regions; for example when 20 samples of wet land type of blackgram were tried in ten Agricultural Research Stations from 1946 to 1948 as an after-paddy crop, the varieties from the Northern districts failed miserably when grown in the southern districts and vice versa.

Cooking tests.—Twenty-two cultures of redgram from Coimbatore, 11 from Salem, and 20 from the Vizianagaram sub-station were analysed by the Agricultural Chemist for proteins and other chemical constituents as well as their cooking quality (Statement No. 8). The protein content ranged from 24·5 to 29·5 per cent on moisture-free basis. Cultures from Salem were found to have a lower protein content than those from Vizianagaram. It was also noted that there was a significant negative correlation between the time taken for cooking and the protein content of these cultures. Thus the Vizianagaram cultures, which had the highest percentages of protein, got fully cooked much sooner than those from Salem and Coimbatore that were also poorer in protein content.

6. *Harvesting, threshing, storing.*—In the case of pulse crops these operations are comparatively easy. Redgram is harvested in six to eight months from sowing time, beginning from December and extending up to March, according to the sowing date and duration of the crop. As redgram plants put forth three flushes of flowers and pods the harvest is to be made when the maximum number of pods are ripe on each plant. The actual harvest is done by cutting the plants close to the ground in order that the stumps may not injure the feet of men and cattle, bundled and taken to the threshing floor, and stooked for about ten days to

allow the pods to get fully dry. The leaves also get shed during this drying. The threshing is done by women by beating the plants against any hard surface, taking two or three plants at a time. The threshed produce, consisting of seeds, broken bits of pods, leaves, etc., is winnowed and bagged after drying. Storage of redgram for prolonged periods is resorted to only in the case of seed grains, for which they are coated with moistened red earth, well dried and stored in earthern pots.

The yield of redgram ranges from 400 to 600 pounds per acre when grown as a mixture and from 600 to 1,000 pounds as a pure crop with rows four feet apart.

In the case of other pulses like blackgram, greengram, bengalgram and horsegram, the plants are pulled when they are ripe, spread out on the threshing floor during the day and kept heaped up during the night. This process is repeated for three or four days by which time most of the pods would have dehisced liberating the grains. The produce is then beaten with sticks or trodden under the feet of cattle according to its bulk and winnowed out with the aid of wind. Storing is done generally in earthen vessels or wooden bins. It is advisable to put a layer of sand half an inch thick on the top of the grains to prevent infection by weevils and other insect pests of stored products. The acre yields of blackgram and other grams are very variable and range from 200 to 600 pounds, depending on the season and the nature of the soil.

7. *Pests and diseases.*—Pulses are liable for attack from pests and diseases both in the field and in storage. An account of the various insect pests and plant diseases that cause damage to pulse crops is given in the Chapters Nos. 22 and 23 under crop pests and crop diseases respectively.

8. *Nutritive value.*—All pulses are rich in protein and are thus useful as a source of protein for those who do not like or who cannot afford the more expensive animal proteins. Pulses are also rich in vitamin B-1. A well-balanced diet should include at least three ounces of pulses every day. The relative food values of different pulses are shown in Statements Nos. 9 and 10.

9. *Future lines of work.*—Although the pulses section started working only in 1943, a number of improved strains of different pulse crops is already in the final stages of tests and would be available for distribution by 1951. These strains are in general able to yield 15 to 20 per cent more than the local types and secure for the grower an extra return of Rs. 20 to 30 per acre. Some work on pulses had been done previously by the Millets and Cotton Specialists, and several high-yielding strains are available at present, in redgram, and bengalgram, cowpea and lablab.

In redgram, 4,020 pounds of high yielding seed have been issued for sowing in the course of the past six years, to cover nearly 600 acres, excluding the area of its natural spread during these

years, which would be at least 3,000 acres. About 200 acres were being grown (in 1949) with strain No. 2900 in Salem under seed farm conditions. Similarly in Bengalgram three high yielding types, Nos. 468, 482 and 2965 were distributed to a total of 10,730 lb. chiefly in Anantapur, Bellary and Coimbatore districts and have been extended in 1949 to Cuddapah and Kurnool as well.

A great deal of work, however, still remains to be done in regard to improvement of pulse crops. There are numerous varieties in each of the major pulse crops, redgram, Bengalgram, blackgram and greengram, many of them with high potentialities in yielding capacity. These require an exhaustive study for picking out the best as high-yielding strains. The evolution of strains for the various pulse tracts on a zonal basis is essential. Hybridization work has also to be taken up for improving the quality and yield in each of the pulses. For example the short-duration redgram variety of Tenkasi (Tirunelveli district) could be crossed with high yielding strains, to combine earliness with good yields. Wilt-resistant types could be crossed with cultivated types of redgram. Seasonal trials have to be undertaken in the different regions to fit in the best strains for each region. The rotation of pulses with cereals, spacing trials, the economics of various types of mixtures of pulses and other crops, manurial studies, cooking tests and studies on quality, investigations on the chemical composition of pulses in relation to climatic regions, soils, and cultural treatments, cytogenetic and physiological studies, are all aspects that deserve careful study over a number of years, if any reliable knowledge is to be gathered. For this it is obviously essential to have a long-range programme of work to be carried out not only at Coimbatore as the main centre but also at two regional sub-stations preferably in East Godavari and Tiruchirappalli for the northern and southern regions respectively. An outline of such a programme is indicated below.

Collection of types—Both wild and cultivated from Madras, India and from other countries if practicable—to serve as basic material for selection work, for hybridization and genetic studies, on the inheritance of various characters including yield factors.

Selection work—To isolate high yielding types suited for each tract.

Hybridization.—To widen the scope of selection and to combine different desirable characters in one and the same strain.

Cytological studies.—To furnish the basis for planned work on hybridization, for inducing mutations by means of Colchicine and other chemicals, by X-rays, high temperatures, etc.

Agronomical studies.—Studies on the regional specificity of pulses, acclimatization of varieties to suit different areas in the State, seasonal trials with pulses in different regions, economics of

pulse-cereal mixtures as against pure crops, rotation experiments with pulses and non-pulses to assess depressing or stimulating effects of one crop on another.

Manurial.—Investigations on the effect of organic and inorganic manures on different pulses, the optimum doses, forms and combinations of fertilizers, the best time of application and the best method of fertilizer placement studies, studies on nutrient deficiencies.

Physiological.—Visual and analytical symptoms of nutrient deficiencies in different pulses, including trace element of deficiencies and the methods of rectifying such deficiencies, the effect of various types of pre-treatment of seeds and seedlings—for increasing yields, the use of growth regulating substances for improving seed setting, preparation of pulses for the market.

Cooking and quality.—Investigations.

Nutritive value of different pulses, both as such and in relation to agronomic, manurial and other treatments.

STATEMENT No. 1.—*Position of pulses in Madras State.*

Crops.	*Area in acres.*	*Production in tons.*	*Consumption in tons.*	*Deficit in tons.*
Redgram	337,500	41,500	1,22,500	81,000
Blackgram	291,100	32,000	63,100	31,000
Greengram	461,000	40,750	60,400	19,650
Horsegram	1,368,000	96,000	125,000	29,000
Bengalgram	84,300	16,500	184,000	167,500
Other pulses	233,000	24,450	28,450	4,000
Total ..	2,774,900	251,200	583,450	332,250

STATEMENT No. 2.—*Imports and exports of pulses in Madras.*

Year.	*Imports.*		*Exports.*	
	Quantity	*Value.*	*Quantity.*	*Value.*
	TONS.	RS.	TONS.	RS.
1932–33	218,988	2,30,95,463	..	..
1933–34	167,384	1,85,61,259	..	..
1934–35	151,549	1,50,71,045	..	..
1935–36	141,104	1,42,75,197	..	..
1936–37	136,975	1,25,80,650	..	..
1937–38	86,476	94,46,549	8,326	2,10,669
1938–39	70,439	76,90,366	10,167	9,35,445

STATEMENT No. 3.—*Effect of a previous pulse crop on cotton yields (Coimbatore).*

Cotton yields in pounds of Kapas per acre.

Treatments.	*Cambodia cotton.* (*Irrigated crop.*)		*Karunganni cotton.* (*Rainfed crop.*)	
			Red soil.	*Black soil*
	1935–36.	1936–37.	1934–35.	1934–35.
Cotton after cholam ..	278	846	399	277
Cotton after cowpeas ..	..	246	* 438	* 313
Cotton after greengram ..	147	..	..	..
Cotton after redgram ..	269	..	..	..

* Significantly higher.

STATEMENT No. 4.—*Effect of previous crop on the succeeding crop of cotton.*

(Agricultural Research Station, Koilpatti.)

Previous crop.	*Yield of seed cotton (Kapas) in pounds per acre.*								
	1928–29.	1929–30.	1930–31.	1931–32.	1932–33.	1933–34.	1934–35.	1935–36.	1936–37.
Sorghum (control) ..	132	427	181	553	697	220	588	289	322
Bajra	..	538	191	696	820	431	..	..	333
Blackgram	* 179	* 522	177	601	..	..	..	..	285
Greengram	* 168	* 497	189	..	..	..	..	..	305
Horsegram ..	* 184	* 488	192	* 633	* 921	* 490	..	..	..
Pillipesara	..	..	..	..	* 991	* 467	495	438	..
Lablab	* 174	* 513	223	..	..	..	..	..	..

* Significantly better than cotton after sorghum.

NOTE.—It would be observed that cotton yields after horsegram are consistently better than cotton after other pulses or non-pulses like sorghum or bajra.

STATEMENT No. 5.—*Effect of a previous pulse crop on cotton yields.*

(Agricultural Research Station, Nandyal.)

Treatments.	*Yield of kapas in pounds per acre.*		
	1921–22.	1922–23.	1923–24.
Cotton after pillipesara	205	320	301
Cotton after sorghum	298	222	184

STATEMENT No. 6.—*Cholam pulse mixture experiments.*

Cotton Breeding Station, Coimbatore (irrigated).

	Number of lines.		*Yield of cholam grain in lb. per acre.*			*Yield of cotton in lb. per acre.*		
	Cholam.	*Pulse.*	1934–35.	1935–36.	1936–37.	1934–35.	1935–36.	1936–37.
Redgram ..	4	0	2,940	..	..	573	..	..
	3	1	3,040	..	..	541	..	..
	2	2	†2,800	..	..	504	..	..
	Mixture.		*3,220	..	..	*593	..	..
Redgram mixed in the same line.	1	0	..	2,525	..	..	385	..
	1	¼	..	2,475	..	..	*472	..
	¾	¼	..	*2,700	..	..	382	..
	½	½	..	*2,700	..	..	381	..
	¼	¾	..	†2,375	..	..	†347	..
Greengram mixed in the same line.	1	0	..	2,413	..	..	*278	..
	1	¼	..	2,275	..	..	241	..
	¾	¼	..	*2,475	..	..	238	..
	½	½	..	2,288	..	..	†200	..
	¼	¾	..	†2,100	..	..	213	..
Cowpea mixed in the same line.	1	0	..	..	*2,841	..	..	*846
	1	¼	..	..	2,444	..	..	*820
	¾	¼	..	..	2,466	..	..	786
	½	½	..	..	2,569	..	..	676
	¼	¾	..	..	†1,628	..	..	†622
Soybeans ..	1	0	..	..	2,841	..	..	846
	1	¼	..	..	2,688	..	..	869
	¾	¼	..	..	*2,875	..	..	867
	½	½	..	..	2,744	..	..	914
	¼	¾	..	..	†1,869	..	..	*908

* Significantly higher yielders.

† Significantly lower yielders.

STATEMENT No. 7.—*Cholam pulse mixure experiments.*

Cotton Breeding Station, Coimbatore, (Rainfed, black soil).

	Number of lines.		*Yield of cholam grain in lb. per acre.*		*Yield of cotton in lb. per acre.*	
	Cholam.	*Pulse.*	1933–34.	1934–35.	1934–35.	1935–36.
Pillipesara ..	4	0	479	†225	†201	..
	3	1	*521	*298	†210	..
	2	2	*516	*299	†157	..
	1	3	507	284	†163	..
	Mixture.	..	†303	237	*307	..
Horsegram ..	4	0	432	..	..	..
	3	1	457	..	..	..
	2	2	462	..	..	..
	1	3	*543	..	..	..
	Mixture.	..	†386	..	..	..
Cowpea ..	4	0	†545	..	277	..
	3	1	†506	..	278	..
	2	2	570	..	319	..
	1	3	*658	..	291	..
	Mixture.	..	572	..	†263	..
Lablab ..	4	0	..	†264	..	280
	3	1	..	347	..	311
	2	2	..	*370	..	259
	1	3	..	†259	..	†221
	Mixture.	..	..	..	..	..

* Significantly higher yielders.

† Significantly lower yielders.

STATEMENT No. 8.—*Relation between protein content and cooking quality in redgram varieties.*

Time taken to get fully cooked (in minutes).	*Protein content (percentages on moisture free basis).*	*Remarks.*
22	28·17	There is a negative correlation between cooking time and protein content, which is statistically significant. Seeds of high protein varieties cooked earlier.
23	28·19	
24	27·51	
25	27·46	
26	26·15	
27	25·79	
28	25·46	
29	25·59	
30	25·54	
31	25·39	
32	25·50	
33	26·04	
34	25·48	
35	26·32	
36	25·69	
37	24·69	
40	26·06	
50	24·57	

Statement No. 9.—*Nutritive value of different pulses.**

	Total protein.	*Biological value.*	*Digestibility.*	*Net protein.*	*Cystine.*	*Tyrosine.*	*Tryptophane.*	*Histidine.*	*Total.*
	1	*2*	*2*	*1*	*1*	*1*	*1*	*1*	*10*
Bengalgram	1	2	2	1	..	1	1	..	8
Greengram	..	..	2	1	1	1	..	1	6
Redgram	..	2	..	1	1	..	..	..	4
Field peas	1	2	..	..	..	..	..	..	3
Lentil	1	..	2	..	1	1	1	..	6
Khesari	..	..	..	..	1	..	..	1	2
Blackgram	..	2	2	1	1	1	..	1	8
Cowgram	1	2	..	..	..	1	1	1	6
Fieldbean	1	..	..	..	..	..	1	..	2
Soyabean	1	..	2	1	..	1	1	..	6
Horsegram	..	2	..	..	..	..	1	1	4

* *The Indian Journal of Agricultural Science*, Volume IX, Part I—From a review of the literature on the nutritive value of pulses. By R. K. Paul, Liaison Officer, between Human Nutrition and Agricultural Research.

STATEMENT No. 10.—*Composition of pulses.**

Name of pulse.	*Moisture.*	*Protein.*	*Fat (ether extractives).*	*Mineral matter.*	*Fibre.*	*Carbohydrate.*	*Calcium.*	*Phosphorus.*	*Iron (mgs).*	*Calorific value per 100 gm.*	*Carotine (international Vit. A units per 100 gm.)*	*Vit. B. 1 (international units per 100 gm.).*	*Remarks.*	*Vit. B-2.*
	PER CENT.	PER CENT.		PER CENT.	PER CENT.	PER CENT.	PER CENT.	PER CENT.	PER CENT.					
Redgram	15·2	22·3	1·7	3·6	..	57·2	0·14	0·26	8·8	333	220	150	Without outer husk.	Good source.
Blackgram	10·9	24·0	1·4	3·4	..	60·3	0·20	0·37	9·8	350	64	140	Do.	Do.
Greengram	10·4	24·0	1·3	3·6	4·1	56·6	0·14	0·28	8·4	334	158	155	Do.	Do.
Bengalgram	9·8	17·1	5·3	2·7	3·9	61·2	0·19	0·24	9·8	361	316	100	Do.	Do.
Cowpea	12·0	24·6	0·7	3·2	3·8	55·7	0·07	0·49	3·8	327	60	..	..	Do.
Horsegram	11·8	22·0	0·5	3·1	5·0	57·3	0·28	0·39	7·6	322	119	..	..	Poor.
Fieldbean (dry) ..	9·6	24·9	0·8	3·2	1·4	60·1	0·06	0·45	2·0	347	Trace.	..	..	None.
Khesari (Langdhal) ..	10·0	28·2	0·6	3·0	..	58·2	0·11	0·50	5·6	351	200	..	..	..

* From Health Bulletin No. 23—The nutritive value of Indian foods and the planning of satisfactory diet 1938.

STATEMENT No. 11.—*List of strains evolved from the Pulses Section.*

(*a*) Strains suitable for the southern districts of Madras.

Pulse. (1)	*Culture number.* (2)	*Duration.* (3) DAYS.	*Average yield per acre as a pure crop.* (4) LB.	*Other particulars.* (5)
Redgram	No. 37	155	800	A selection from Tiruppathur variety (North Arcot district). Yields 30 per cent more than the local type. The gram is bold and attractive in colour. Suitable for growing in all the southern districts of the State.
Do.	No. 1723	165	500	This is a selection from the Coimbatore local type, yielding 15 per cent more with an average of 500 lb. per acre.
Do.	No. 2900	160	600	This was isolated from a cross between Arhar and local (Coimbatore) variety. The seed is bolder than in No. 1723. Suitable for Salem, Coimbatore, Chittoor, Guntur and the Ceded districts.
Greengram	No. 62	120—130	400	Yields 25 per cent more than the local Coimbatore type, from which it is a selection. Suitable for sowing both in early and late seasons on dry lands.
Bengalgram	No. 482	100	600	Selection from local Coimbatore type, suitable for growing in Coimbatore, Guntur and Ceded districts. Grows well even when sown late.
Do.	No. 2965	110	500	Isolated from a cross between types T. 3 and T. 493. Grain is bold in size with an attractive light colour.
Horsegram	No. DB. 7	140 (if sown in October).	600	Selection from Coimbatore local type, suited for growing in nearly all the southern districts. The seed is cream-coloured with brownish spots.
Do.	No. 35	135	800	A buff seeded selection from Coimbatore local type.
Cowpea	No. C. 57	95	500	Suitable for grain and green manure.
Do.	No. C. 419	90	1,000 (green pods as irrigated crop).	Selection from a Ganjam variety. Suitable for use as a vegetable. The pods are long and fleshy, sweet and light yellow in colour. Can also be grown as a rainfed crop.
Do.	No. C. 422	60	(Best for green manure).	Selection from Coimbatore local. Quick growing, within two months give a heavy yield of green matter. Suitable for green manure.

Do.	No. C. 521	..	500	Selection from a sample from Tanganyika; the gram is light brown in colour and bolder than C 57.
Lablab (Field variety)	No. DL 173	160	600	Selection from Coimbatore local. Seed white.
Do.	No. DL 231	160	800	Selected from an Udumalpet variety. Seed is broad and buff coloured
Lablab (kitchen garden variety)—				
	DL 238	..	..	Pods medium in size, purple in colour.
	DL. 239	..	..	Pods small, narrow, green.
	DL 244	..	..	Pods, small, medium and light yellow in colour.
	DL 247	..	..	Pods short, narrow and green.
	DL 250	..	..	Pods broad, edges purple tinged, very delicious.
	DL. 259	..	..	Pods green in colour, broad-shaped.
	D.L. 268	..	..	Pods green, narrow, long.
	D.L. 269	..	..	Pods broad, purple, mixed with green here and there.
	DL 277	..	..	Pods purple, long and medium (broad).
	DL. 279	..	..	Pods narrow, purple with green mixed, short.
	DL 288	..	..	Pods light green in colour, medium and narrow.
	DL. 319	..	..	Pods, broad, purple.
	DL 326	..	..	Pods very small and green, short and narrow.
	DL 338	..	..	Pods long, green in colour and medium.
	DL. 389	..	..	Pods purple, medium broad and thick.
	DL. 453	..	..	Pods deep purple slightly broad.
	DL. 692	..	..	Pods cream in colour, long narrow and bloated.
	DL. 1173	..	..	Pods light green, slightly broad and long.
	DL. 1174	..	..	Pods cream coloured, flat, long and broad.
	DL. 1188	..	..	Pods purple, broad and long.
	DL. 1191	..	..	Pods purple, medium and short.
	DL 1337	..	..	Pods broad, short with purple margins.

(*b*) Strains suitable for the Northern districts of Madras (evolved from the Pulses Breediug Sub-Station, Vizianagarm).

Red gram	No. 97	200—220	800	Late strain, suitable for all districts in the Circars. Yields 30—3 per cent more than ryotrs' seed.
Blackgram	No. 189	120	400	Selection from a dryland type of Visakhapatnam. Yields 25 per cent more than the local type.
Green gram	No. 127	90—95	400	Suitable for growing as a dry land crop in the Northern Circars. Yields 20 to 30 per cent more than the local type.
Horsegram	No. 76	150 (when sown in October).	500	A buff-seeded selection.
Do.	No. 93	135	600	Black-seeded type, earlier than No. 76 by two weeks.

CHAPTER 6.

OIL SEEDS OTHER THAN COCONUT.

GROUNDNUT (*Arachis hypogœa*).

Groundnut.—Area, varieties, trials, selections, hybridization—Agronomic trials—Decortication and storage studies—studies on oil content and keeping quality—Marketing standards work at Research Stations—Fundamental studies and physiological investigations—Genetics and Cytology.

Gingelly.—Area, cultivation, varieties, trials—selection, hybridization—Agronomic studies—Fundamental work—Oil content and factors affecting quality and quantity.

Castor.—Exports and imports—Trials, varieties and strains evolved—Genetic and physiology.

Other oilseed crops.—Safflower—Oil palm, Tung oil tree.

Family — *Leguminosœ*. Tamil — *Verkadalai*. Telugu — *Verusanagulu*. Malayalam — *Nelakkatala*. Kannada — *Nelagadale*. Hindi — *Vilayitimung — Mung-phali*.

Production and importance.—The area under the groundnut in the Indian Union is about ten million acres with an estimated annual production of 3·5 million tons of pods (nuts in shell). The State of Madras accounts for as much as 40 per cent of the area and 46 per cent of the production of the entire Indian Union and is thus, by far the most important groundnut producing area in India. Hyderabad and Bombay also have an appreciable share in acreage and production. The crop is raised almost throughout the Madras State, excepting the districts of Nilgiris and South Kanara.

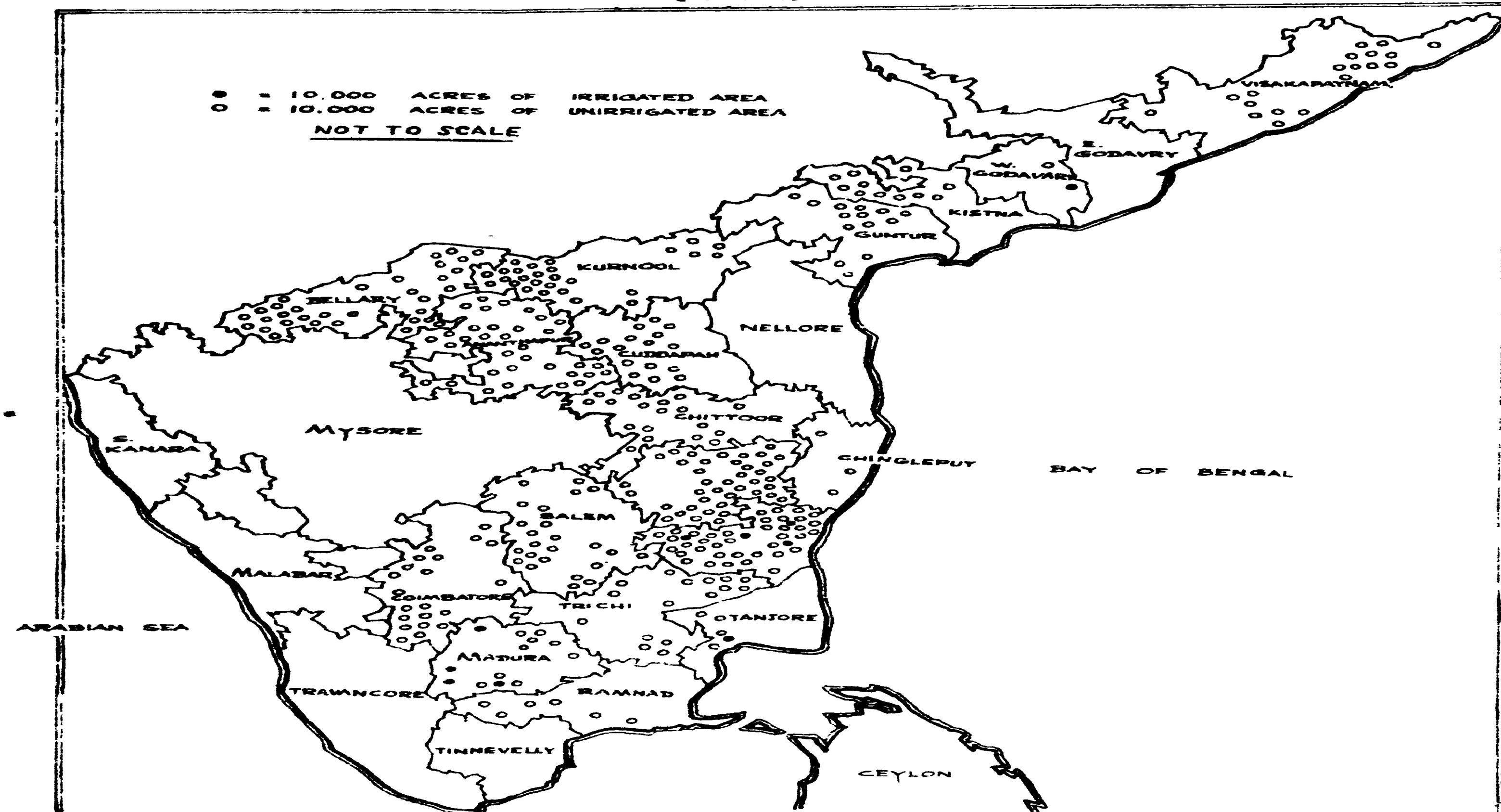
The increase in the acreage under groundnut in Madras has been really phenomenal. From a bare two lakhs of acres in 1900, the acreage increased by leaps and bounds and touched the peak figure of 4·7 million acres in 1937–38. Later on there was a marked decline during war years. At present, the area is roughly four million acres. The following statement gives the area and production of groundnut in Madras during the past 14 years ending 1948-49.

STATEMENT I.—*Estimated area and production of groundnut in Madras.*

Year.	Area in thousands of acres.	Production (nuts in shell) in thousands of tons.
1935–36	2,525	1,204
1936–37	3,495	1,657
1937–38	4,658	2,059
1938–39	3,772	1,613
1939–40	3,618	1,722
1940–41	3,422	1,924

DISTRIBUTION OF GROUNDNUT CROP IN MADRAS STATE

(1948-49)



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Helio P. Z. P., C. S. O., Madras.

STATEMENT I.—*Estimated area and production of groundnut in Madras*—cont.

Year.	Area in thousands of acres.	Production (nuts in shell) in thousands of tons.
1941–42	2,784	1,183
1942–43	3,382	1,304
1943–44	3,550	1,603
1944–45	4,300	1,952
1945–46	4,165	1,564
1946–47	4,121	1,690
1947–48	4,067	1,601
1948–49	3,970	1,614
(Estimated forecast).		

The area under the groundnut is influenced by a number of factors like timely sowing rains, favourable prices at the sowing time and Government restrictions. South Arcot, Kurnool, North Arcot, Bellary, Anantapur and Guntur are the more important groundnut growing districts in the Madras State. (Plate 29.)

Exports—Kernels and oil.—In the earlier years of this century, when the industrial development in India was still in its infancy, India was exporting a major part of the produce to foreign countries and was having a large share in the international trade in groundnuts. With the development of oil crushing and vanaspathy manufacturing industries in India, larger and larger quantities began to be consumed in the country itself and the exports fell. Further, after the war, exports as kernel were restricted by Government. The quantity of kernels exported from Madras State declined from 8·8 lakhs of tons during 1938–39 to only 3·3 lakhs during 1945–46, and to only about 31,000 tons during 1948–49. In the same period exports as oil are estimated to have increased from 45,000 tons during 1944–45 to 91,000 tons during 1948–49. The Statements II and III give the figures for the exports of groundnut kernels and oil respectively.

STATEMENT II.—*Export of groundnut kernels* (1,000 *tons*).

Year.	By sea foreign.	By sea to other States.	Estimated by rail to other States.	Total.
1938–39 (pre-war)...	817	5	62	884
1944–45	215	15	71	301
1945–46	197	7	126	330
1946–47	..	4	1	5
1947–48	29	2	4	35
1948–49	30	..	1	31

STATEMENT III.—*Export of groundnut oil* (1,000 *tons*).

Year.	By sea foreign.	By sea to other States.	Estimated by rail.	Total.
1944–45	1	16	28	45
1945–46	1	13	45	59
1946–47	18	19	17	54
1947–48	20	17	39	76
1948–49	32	20	39	91

Scope for production.—The Panel on oils and soaps industries constituted by the Government of India, after a detailed study of the problem, has recommended an increased production of 5·4 million tons of pods for the whole of India for utilization as follows :—

For export—one million tons of kernels.

For internal crushing—2·6 million tons of kernels.

There is also considerable scope for increased consumption of groundnut as dessertnut in our country.

In the Madras State an increased production of groundnuts to the extent of about 20 per cent can be achieved by adopting various measures. The chief among them are, growing groundnuts as a mixture crop with cereals in dry lands, as a rotation crop in the Modan lands of Malabar and as a rotation or a second crop after the harvest of paddy in the wet lands of most districts, especially in the Cauvery, Godavari and Krishna deltas, without in any way encroaching on the area under paddy or disturbing the paddy cropping.

Effects of climate and soil on the yield and quality of groundnuts.—It is recognized that the yield as well as the qualitative characters of groundnut like shelling percentage (proportion of kernels to pods by weight) natural test weight (weight per unit volume) size of kernels, percentage of oil and free fatty acids are influenced by climatic and soil variations; but practically nothing was known regarding the extent to which they were influenced. In order to gather information on these aspects, six groundnut pure lines were grown for three consecutive seasons in about 30 Agricultural Research Stations distributed throughout the length and breadth of India. Samples were received from each of the stations and were analysed in detail for the various factors. In 27 Research Stations, one or more of the pure lines gave significantly increased yields over the local varieties and have become popular. Important conclusions drawn from the study of qualitative characters are as follows :—

(1) All the characters studied are seen to be greatly influenced by the rainfall and its distribution during the period of the growth of the crop.

(2) The nature of the soil and its capacity to retain moisture comes into prominence only when the rainfall is excessive, low or badly distributed.

(3) Characters such as natural test weight of pods, natural test weight of kernels and size of kernels, though highly influenced by environmental conditions, are essentially varietal in nature.

(4) Shelling percentage is equally varietal and environmental in nature.

(5) Free fatty acids content is purely environmental in nature and is dependent upon seasonal conditions at the time of harvest and subsequent handling of the produce.

Plaet 30 (*a*).—*Strains of Groundnut.* *A—TMV* 1 (*A.H.* 25)—*Spreading.* P. 212

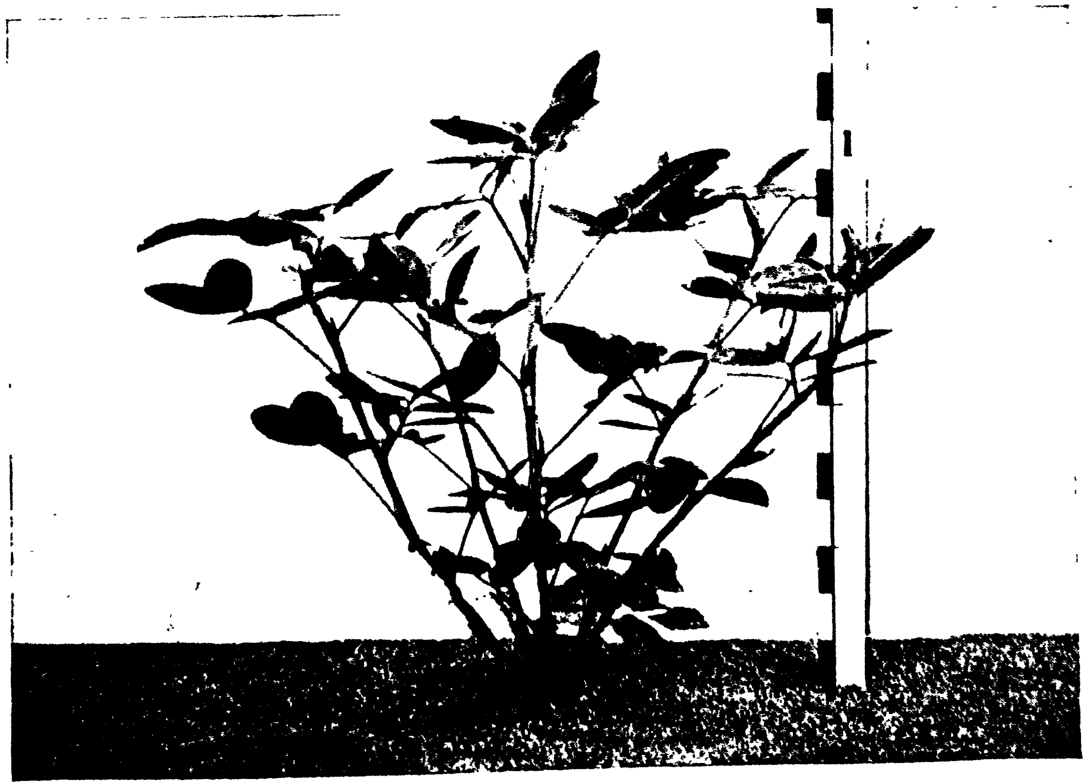

Plate 30 (*b*).—*Strains of Groundnut.* *B—TMV* 2 (*A.H.* 32)—*Bunch.*

P. 213

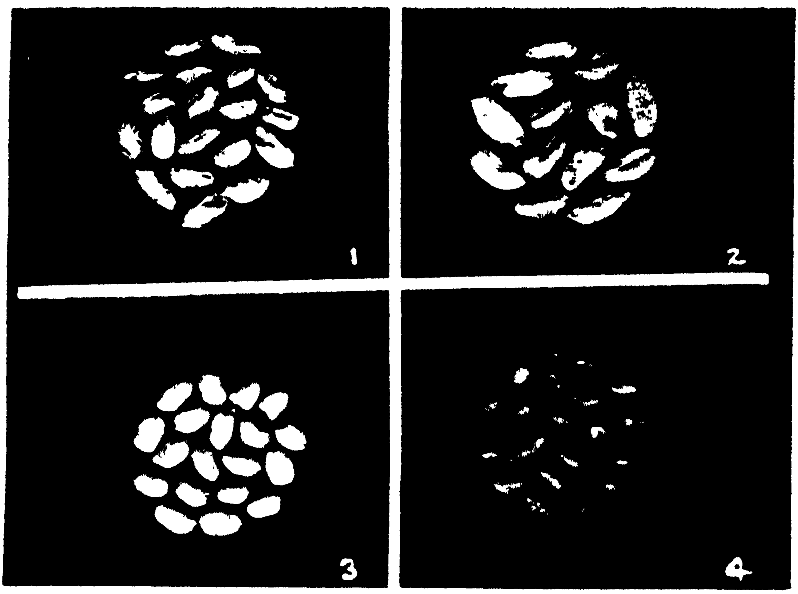

Plate 31.—*The principal commercial kinds of groundnut cultivated in India.* P. 214

1. *Coromandel or Mauritius.* 2. *Bombay Bold.*
3. *Spanish Peanut.* 4. *Small Japan or Pollachi Red.*

(6) Oil content which is a varietal character is also found to be fluctuating even up to seven per cent from season to season.

Varieties cultivated.---The important varieties cultivated in Madras are the Coromandel also known as Local Mauritius or Mozambique Mauritius, the Spanish Peanut and the Pollachi Red. Coromandel is a long duration (4½ months) spreading variety while the other two are short duration (3½ months) bunch varieties. Coromandel accounts for as much as 80 per cent of the groundnut area of the State. The share of the Spanish Peanut and Pollachi Red comes to about ten per cent and three per cent respectively. There is another commercially important variety, viz., Bold (Big Japan). This, while practically unknown in Madras, accounts for over 50 per cent of the area in the Bombay State. In recent years the improved strains of groundnut, viz., TMV 1, TMV 2, and TMV 3 released by the Oil Seeds Specialist, Department of Agriculture, Madras, are also being cultivated increasingly in a number of districts. (Plates 30 and 31.)

Evolution of strains—(A) By selection.—As a result of intensive crop improvement work the following improved strains of groundnut have been evolved. They have been extensively tested in ryots' holding in a number of districts and have been found to be definitely superior to the local varieties in the matter of yield, oil content, etc., the increase in yield being well over 25 per cent (Statement A). The special attributes of these strains are summarized below :—

TMV 1 (*A.H.* 25).—This is a mass selection from "Saloum" a West African spreading variety. This is a high yielding strain yielding more than 25 per cent over the "Local Mauritius" variety. It is best suited for growing during the rainfed season (July to December) and is a drought resistant type. On account of the smooth cylindrical nature of pods, harvesting is comparatively easy and less costly than the ryots' variety, as most of the pods remain attached to the plant when lifted out of the soil. It has also been found to be more resistant to "Surul" attack than "Local Mauritius".

TMV 2 (*A H* 32).—This is a mass selection from a Spanish type. This is a strain with bunch habit of growth and yields even as much as the spreading variety in years of well distributed rainfall. It is the shortest duration type among the groundnut varieties and comes to maturity in 105 days. This strain is particularly suited to tracts where the monsoon period is short or where two crops are taken during the main rainfall season. Being a bunch variety it is very easily harvested.

TMV 3 (*A.H.* 698).—A strain isolated from the West African variety Bassi. This is another high yielding strain with spreading habit of growth, giving over 25 per cent increased yield over the local variety. It has a higher shelling outturn than A.H. 25 and the ryots appreciate if on account of its high natural

test weight (weight per unit volume). It has given very good yields in Salem, South Arcot, North Arcot, Chittoor and Chingleput districts.

TMV 4 (*A.H.* 334).—A selection from an American variety *Carolina*. This is another spreading strain of groundnut, capable of giving more than 25 per cent increased yield over the " Local Mauritius ". This is specially recommended to be grown under irrigation during summer (March–July). It has a larger proportions of three-seeded pods.

All these improved strains being definitely superior to the local varieties are expected to bring, on a modest estimate, an extra remuneration of Rs. 50 per acre to the cultivator. Realising the benefits that would accrue to the ryots, the Government have sanctioned a scheme of seed multiplication of the strains with a view to making large quantities of seeds available to the ryots.

The following are a few of the promising selections evolved recently (Statement B) :—

(1) *AH.* 4111.—This is a pure line selection from the local bunch variety, " Gudiyatham Bunch ". It is a short duration type with an erect habit of growth. It cannot stand long periods of drought. Kernels are small, light rose, rounded, plump and non-dormant, i.e., they do not require any period of rest after harvest and before germination.

(2) *AH.* 4205.—This is a pure line selection from the local bunch variety, " Gudiyatham Bunch ". It is a short duration type with erect habit of growth. It cannot stand long periods of drought. Kernels are small, light rose, rounded, plump and non-dormant.

(3) *AH.* 4218.—This is a pure line selection from the local bunch variety, " Gudiyatham Bunch ". It is a short duration type with erect habit of growth. It cannot stand long periods of drought. Kernels are small, light rose, rounded, plump and non-dormant.

(4) *AH.* 4515.—This is a pure line selection from the South American variety *Casilda* 5. It is a short statured very early maturing type with an erect habit of growth. It cannot stand long periods of drought. Kernels are small, light rose, rounded, plump and non-dormant.

(5) *AH.* 2105.—This is a pure line selection isolated from the West African variety " Native Tanganyika ". It is a medium duration type with semi-spreading habit of growth. Kernels are medium, rose, elliptic, not plump and dormant.

(6) *AH.* 3711.—This is a pure line selection from the local variety grown in the Salem district. It is a medium duration type with spreading habit of growth. Kernels are small, rose, round not plump and dormant.

(7) *AH.* 4354.—This is a pure line selection from variety " Spanish Bombay ". Plants are vigorous with semi-spreading habit of growth. They do well in years of well distributed rainfall. Kernels are medium, rose, elliptic, not plump and dormant.

Trials with these promising selections will be arranged in the districts to study their performance in detail in ryots' lands.

(B) *By hybrdization.*—As certain economically important characters like yield, shelling percentage, dormancy of seeds, habit of growth, etc., are not found associated in varieties suited to the particular needs of different localities, extensive inter and intra-varietal (within variety) hybridization work has been started and is in progress. Crossing between selected varieties of *Arachis hypogaea* and other species like *A. nambyquarae* and *A. Rasteiro* has been made. The progenies of inter specific crosses proved uneconomic in many respects.

Intensive hybridization work carried out with the object of evolving a short duration bunch strain with dormant seeds to meet the needs of the tracts like Guntur, Pollachi, etc., so as to eliminate loss due to sprouting of seeds in the field at maturity, has yielded a strain with the desired attributes. It is *AH.* 6481 which is a selection from a cross between the local bunch and Native Tanganyika. It has a bunch habit of growth with short duration and gives more than 15 per cent increased yield over the local bunch. Kernels are medium, rose, elliptic, somewhat plump and dormant. (Statement A.)

Average acre yield of pods	1,250 lb.
Shelling percentage	76
Weight of one Madras measure of pods ..	1 lb. 4¼ oz.
Weight of one Madras measure of kernels ..	2 lb. 13 oz.
Number of kernels per pound	1,058
Oil content of kernels (on moisture free basis).	49 per cent.
Duration	110 days.

It is proposed to multiply the seeds of this selection and conduct extensive district trials in Guntur and Pollachi tracts.

Crosses to evolve a strain with spreading habit of growth with high yield and thin shell, i.e., giving high outturn of kernels have been effected and the work is in progress.

Evolution of a large seeded type for edible purposes.—The per capita annual consumption of groundnut in Madras is estimated at 3·4 lb. of pods. This shows that there is scope for considerable expansion. As groundnut cultivation developed in this State on account of keen foreign demand for industrial purposes only commercial types with high oil content were introduced. So far no attempt has been made to encourage cultivation of large kernelled types suitable for eating. Groundnuts for edible use should be big sized with low oil content and good flavour. Nine large seeded varieties weighing about 800 kernels per pound as against 1,200 kernels per pound of the ordinary ' variety ', were under comparison for yield uniformity in size and shape of kernels and oil content. Though from the point of view of yield, the results have not been conclusive, it was found that *Arachis nambyquarae* gives five to six per cent less oil than the others and this is a desirable character in desert nuts.

Agronomic trials—Cultivation of groundnut—in general.—The groundnut crop is mostly raised under rainfed conditions from June-July to December–January, the time of sowing depending upon the receipt of South-West Monsoon rains. It is also cultivated as a summer crop under irrigated conditions from February-March to June-July in a few districts. The crop is grown on a variety of soils. The sowing is done either in lines behind a country plough or by means of a seed drill. The seed rate varies from 60 to 100 lb. of kernels per acre depending upon the habit of growth and size of kernels. Optimum seed rates have to be used to obtain good yields. Normally two intercultivations are given. The crop is harvested when the vines begin to turn yellow and the inside of the shell turns dark. The short duration bunch type is harvested by pulling out the plants with hand. In the case of the long duration spreading type, the plants are dug and removed with a spade (*mammuti*) and the nuts left in the soil are subsequently gathered. In parts of Ceded districts, the plant is uprooted by working a blade harrow (*Pedda Guntaka*). Some times when the soil hardens, it may be necessary to work the country plough before either digging with a spade or working the blade harrow. Hence harvest of the spreading type is both laborious and expensive.

(1) *Cultural experiments.*—It is usual to give two to eight ploughings with country plough to the fields before sowing groundnut. There are no experimental data to show the optimum number of ploughings necessary for raising a good crop of groundnut. To find out the most economic cultivation practices to be followed for the groundnut crop, a cultural experiment with the following four main tillage treatments and two intercultivation treatments were carried out on the bunch and spreading strains of groundnut :—

Tillage treatments—

Ploughing once with country plough.
Ploughing twice with country plough.
Ploughing thrice with country plough.
Ploughing four times with country plough.

Intercultivation treatments—

Hoeing and weeding once (at flowering time)
and weeding twice (the first at flowering time and the second a month later).

The results indicate that ploughing is beneficial and that "two hoeings and weedings" is better than "one hoeing and weeding."

To determine the optimum number of ploughings required and to find out the feasibility and economics of substituting ploughings with cultivation by cultivator, a new experiment with nine treatments has been started from 1948–49.

(2) *Spacing and seed rate experiments.*—Seed rate being an important item in the cost of cultivation of groundnut it was considered necessary to determine the economic seed rate to be used for the crop. With a view to determine the optimum spacing

and the economic seed rate to be adopted, spacing and seed rate experiments were carried out for over seven years. A spacing of nine inches either way has been found to be the best for spreading varieties under rainfed conditions; bunch varieties give maximum yield when spaced 6 inches apart. This works out to a seed rate of about 75 lb. of picked kernels per acre for the spreading and 100 lb. for the bunch types. This seed rate is being advocated in all the districts where low seed rate is adopted. The ryots have begun to realize the advantages of using higher seed rate, viz., higher yield, uniform maturity and good quality of produce. This improvement was particularly spectacular in the Visakhapatnam district where a low seed rate of about 30 to 50 lb. of kernels per acre had been previously used.

(3) *Mixed cropping experiments.*—Comparison of a pure crop of spreading groundnut with six other mixtures of groundnut and other crops showed that mixed cropping was more remunerative than pure cropping. Among the mixtures tried groundnut-cotton, groundnut-castor, groundnut-sorghum and groundnut-redgram were the most remunerative. Of the crops grown mixed with groundnut, sorghum depressed the yield to the maximum extent (50 per cent) while the minimum of depression in yield of groundnut (19 per cent) was observed when grown with tenai. The experiment was repeated with a bunch variety of groundnut to see how it fared under mixed cropping. The depression in yield suffered by the bunch groundnut by the mixed cropping, was comparatively less than that observed in the spreading groundnut. This is probably due to the high initial rate of growth of the bunch groundnut which helps it to minimise the effects of the subsidiary crop. Even in this series of experiments, the depressing effect of sorghum on the bunch groundnut was the highest. A third series of experiments to study the effect of mixed cropping of bunch and spreading 'varieties' of groundnut with sorghum, bajra, redgram and castor grown in the same season has been started.

(4) *Rotation experiments.*—Precise information on the influence of groundnut on the cereal crops rotated with it in dry lands, and vice versa is lacking. A rotation experiment with bunch and spreading varieties of groundnut carried from 1945–46 season has shown that cereals following groundnuts have given markedly better yields than cereals following cereals. The desirability of including groundnut in regular rotation in dry land cropping has been established from experimental data. It reduces soil erosion and improves the fertility status of the soil.

(5) *Manurial experiments.*—Continuous cropping of the same land with the groundnut without manuring has been found to result in poor yields, the difference in the yields being very marked in years of poor rainfall. The first series of experiments carried out in loamy soils on N, P and K (Nitrogen, Phosphorus and Potassium) basis with and without a basal dressing of cattle manure showed that the groundnut crop responded well to the

application of potash and phosphoric acid and also to cattle manure. However, the doses adopted, namely, potassium sulphate at 1 cwt. per acre and super phosphate at 2 cwt. per acre did not prove economic. Therefore it is necessary to find out the optimum and economic doses of these manures and the cheapest forms in which they can be applied.

(6) *Flat* versus *ridge system of cultivation.*—Groundnut is usually sown behind a country plough and covered by passing a *brush harrow* (branches and twigs tied up into a bundle). This is the "flat system" of cultivation which is largely in vogue. But groundnuts are also reported to be sown on ridges in other countries. This kind of cultivation, i.e., the "ridge system" is practically unknown in this country. An experiment was laid out at the Agricultural Research Station, Tindivanam, to find out which is the more economical of the two systems of cultivation. The trials showed that the flat system of growing groundnut is to be preferred to the ridge system of cultivation and that the latter is neither possible nor necessary for a rainfed crop during the rainfed season.

At the Agricultural Research Station, Palur, a similar experiment was carried out for two years during the summer season, definitely proved that the flat or bed system of cultivation resulted in more yield than the ridge system.

(7) *Electroculture of groundnut.*—It was at one time claimed that electroculture could be made use of to increase the yield in all crops. Experiments conducted on groundnut included sowing of seeds previously soaked in "sparked water" and irrigating the plots with 'sparked' and "onionised" water. There was no increase in yield due to electroculture treatments.

Pests and diseases.—The pests and diseases attacking the crop are dealt with in the chapters on "Crop Pests" and "Crop Diseases".

Harvesting and yields—(1) *Proper stage of harvest.*—Trials conducted to determine the proper stage of harvest of the crop have shown that the maximum yield and the best quality of produce are obtained only when the crop is harvested when it is fully mature, as indicated by the yellowing of leaves and the development of dark colour inside the shell of the pod. Too early a harvest, even by a week, as practised in some of the districts like South Arcot, North Arcot, etc., is found to result in low yield, high percentage of shrivelled kernels, low oil content and high free fatty acid content which in turn bring down the market value of the produce.

(2) *Harvesting and curing trials.*—Different practices of harvesting and curing of groundnuts are being followed in the different districts of the State and also in other groundnut growing countries of the world. To assess the relative effects of a few of

the more important ones on the quality of the produce, the following three treatments were under trial:—

(a) Plants pulled out with pods intact and left in the field for about a week

(b) Plants pulled out and pods stripped immediately and dried

(c) Plants pulled out with pods intact and staked on poles in the field for about a week

Representative samples drawn from the different treatments were analysed for oil, free fatty acid content and germination. It was found that treatment (c) is slightly better than the other two, in regard to oil content of the kernels.

(3) *Duration and yields.*—In groundnut, the early varieties have a duration of 105 days and the late ones up to 135 days. Bunch varieties are in general shorter in duration. Under rainfed conditions the normal yield ranges between 1,000 to 1,250 lb. of pods per acre; under irrigation 3,000 lb. per acre are obtained.

Decortication and storage—Investigation of the working of groundnut decorticators.—With a view to finding out if the proportion of 'splits', 'brokens' and 'nooks' that occur at present in decorticated kernels can be reduced to any appreciable extent by effecting improvements to the existing type of decorticators, an enquiry into the working of groundnut decorticators at representative decorticating centres of the important groundnut growing districts of the State was conducted. Kirloskar's *Kalyan*, Dandekar's *Sangli* and P.S.G.'s decorticators were found to be the more important makes in general use. The first is a grate type while the other two are beater types. The grate type of decorticator is reported to be the best as it gives greater outturn and lower percentage of broken kernels. The high percentage of split and broken kernels now met with in commercial samples of decorticated groundnuts were found to be due to (a) working of decorticator at high speed, (b) using incorrect size of sieve, (c) non-replacement of worn-out parts, (d) absence of regulated feeding of pods into the decorticator and (e) failure to adjust the machine to suit the size of pods fed into the decorticator.

Storage—(A) Storage of pods—(1) *Deterioration of groundnut stored as pods and kernels.*—Groundnuts are stored either as pods or as kernels depending on the quantity to be stored, the use to which it will be put to, and the facility available for storage. To find out which keeps better under storage and which of the containers are best suited for their storage, the rate of deterioration of groundnuts stored as pods and as kernels, loose and in containers such as gunny bags, basket bins and mud bins was studied. Groundnut stored as kernels showed marked increase in damaged fractions, insect attack and acidity when compared with groundnut stored as pods. The total loss due to drying and insect attack was

also high in the case of kernels. The loss worked out to 6·2 per cent as against 4·3 per cent recorded for pods. Among the different containers tried, mud bins appeared to be the best for storing kernels. In the case of pods, no marked difference due to storing in different containers was noticed, probably because of the protective shell.

(2) *Shell thickness in relation to keeping quality in groundnuts.*—Groundnut varieties can roughly be grouped into three classes on the basis of shell thickness. It is a fact that shells afford some protection to kernels against insect pests. But whether this affords similar protection against the absorption of moisture from the atmospheric was not clear. Small quantities of pods with kernels of a variety with thin shells (0·9 m.m.) and another with thick shells (1·5 m.m.) were exposed to controlled varying conditions of atmosphere humidity, viz., 50, 75, 100 per cent. The course of absorption of moisture was traced in all cases till the kernels attained hygroscopic equilibrium with the atmosphere. The data showed that the trend of moisture absorption was almost the same in both the varieties and that the thickness of the shell did not appear to affect absorption in any way.

(3) *Storing unshelled groundnuts.*—The storing of groundnut pods becomes a necessity when a ryot is not able to dispose of his produce immediately after harvest or when he has to use them for seed, the next season. The following points have to be borne in mind in such storage.

Groundnuts intended for storing should be well dried and free from all damaged and diseased pods. Drying in the open sun in thin layers for about a week after harvest, till the kernel inside becomes crisp, is considered advisable. While drying, care should be taken not to trample the pods and crack them.

The most convenient method of storing large quantities of groundnuts is to pack them in good gunny bags which are clean, dry and free from all insects. The bags may be stored in a dry room and it is a good precaution to keep the bags raised from the floor or to cover the floor with a 6-inch layer of clean dry sand, if the bags are to be kept on it directly. The bags may be arranged one over the other so that they do not touch the bare walls. A layer of dry ash about a foot in width may be spread around the heap of bags.

If gunny bags are not available, the unshelled nuts may be stored in heaps in a room. Before heaping, a layer of dry sand, or dry groundnut husk or paddy husk or paddy straw at least half-a-foot thick, should be spread on the floor and a mat put over this.

Small quantities of pods are best stored in pots or baskets smeared over with cowdung, in wooden boxes or in receptacles made of earthern rings. In such cases, it is advisable to fill the container to the top and seal it with a plastering of mud.

In any kind of storage, the produce should be taken out periodically and dried in the sun. When this is done, the store

room and the containers must receive a thorough cleaning. Groundnuts intended for seed should not be kept for more than a year.

(B) *Storage of kernels*—(1) *Rate of deterioration of the produce of winter and summer crops.*—Groundnut is generally raised as a winter crop under unirrigated conditions from July to December, with the help of the monsoon rains. It is also grown on a small scale in certain districts, as a summer crop under irrigation from February-March to July. The crops are harvested at different times of the year and stored during different seasons. The produce of the winter crop which comes to the market in December-January has generally a dry period of storage, while that from the summer crop which arrives in the market in July-August is stored during rainy months.

The produce of the summer crop was found on storage to undergo deterioration much more rapidly than the winter produce. Insect incidence and loss of produce recorded after ten months storage were high in the case of summer produce when compared with that of the winter produce. Summer produce contained a higher percentage of oil, about three per cent more than the winter produce. Judging from the poor keeping quality and greater loss due to drying and insect attack, it is considered undesirable to store the produce from the summer crop for long periods.

(2) *Effect of storing well dried and partially dried kernels.*—Even though it is generally admitted that all produce intended for storage should be well dried, it is not uncommon to store partially dried material. Storage studies conducted on partially dried and well dried kernels showed that the moisture content of the produce at the time of actual storage was the most important predisposing factor of deterioration of groundnut in storage. The partially dried kernels of both the Peanut and Coromandel varieties developed heat soon after storage and deteriorated at a much faster rate than well dried kernels. Peanut variety showed more caking up than the coromandel variety. Even though insect incidence appeared to be more in the fully dried kernels in the early stages of storage, the position was reversed as the storage progressed, the partially dried material being more affected by insects than the fully dried kernels. The loss of material due to drying and insect attack at the end of ten months storage from every bag of kernels of 177 lb. was 17 lb. for Peanut variety and 28 lb. for Coromandel variety as against 12 lb. and 17 lb. respectively for the fully dried material of the two varieties. It was also noted during the course of the studies that deterioration, insect attack and loss were considerably more in the border bags than in the central ones. The study has shown that for safe storage the initial moisture content should not be more than 5 per cent.

(3) *Deterioration of groundnut in relation to initial moisture content.*—An experiment to study the progress of deterioration of groundnut kernels in relation to the initial moisture content was carried out. Kernels from pods (wet) as

they were found at the time of harvest, kernels from pods dried from one to three days in the sun, kernels from partially and well dried pods were stored in gunny bags and samples drawn and studied periodically for content of oil and free fatty acid. Records of temperature of the kernels in the bag were also kept with a view to finding out the degree of fermentation going on. The results showed that even three days drying in the sun was inadequate. The wet kernel increased in acidity and suffered loss in oil content, both of which are undesirable from a commercial point of view. The experiment also showed the danger of even storing dried and wet kernels in close proximity. The necessity for the thorough drying of the produce before storing to keep up quality was well brought out by this experiment.

(4) *Study of development of free fatty acids content in commercial groundnuts under normal storage conditions.*—Machine decorticated kernels generally marketed are found to contain components like "*wholes*" (whole kernels), "*splits*" (kernels split into two), "*nooks*" (pieces less than 1/8 kernel), damaged and shrivelled kernels in varying proportions. The susceptibility of the different components to deterioration in storage was studied in detail. Samples of "Coromandel Mozambique" and "Khandesh Peanut" from the Bombay godowns were received every fortnight. They were separated into the different components mentioned above and estimations of oil and free fatty acid contents were made for each component separately. The experiment was in progress for a period of ten months. The results conclusively showed that the rate of development of free fatty acids was least in the whole kernels followed by splits and immatures while it was maximum in nooks and damaged kernels. It was thus concluded that to improve the quality of groundnuts, nooks should be removed by sieving or other means and the damaged kernels should be picked and removed.

(5) *Deterioration of kernels having varying proportion of "wholes".*—To find out how the proportion of whole kernels stored contributes to the deterioration of the commercial grade of kernels in storage, the rate of deterioration of kernels having 100 per cent, 75 per cent, 50 per cent and 25 per cent "whole" kernels was studied. Kernels with 100 per cent "wholes" recorded minimum increase in acidity and insect attack while those with only 25 per cent "wholes" gave maximum values. The loss due to drying and insect attack during the ten months period of storage was 9 lb. (for every bag of 177 lb.) in the case of 100 per cent "wholes", and 20 lb. in the case of produce having only 25 per cent "wholes". Of the different components of decorticated kernels, "splits" and "broken" fractions were found to deteriorate more quickly than "whole" kernels. From the results it is evident that deterioration and damage in storage can be minimised considerably by storing kernels with a high proportion of "wholes".

(C) *Godowns and storage*—(1) *Effect of storing kernels in well-aerated and properly-cleaned godowns.*—The rate of deterioration of groundnet kernels stored under ordinary godown conditions was compared with that stored in a well-ventilated and periodically cleaned portion of the same godown by proper partitioning. The general trend of development of acidity and damage was almost similar in both the cases. However, in the matter of insect incidence, the material inside the well-ventilated enclosure showed comparatively less infestation in the early stages than the material stored under ordinary conditions. But as storage progressed this difference was gradually reduced probably due to the migration of storage pests from the adjoining infested portion of the godown.

(2) *Rate of deterioration of kernels stored in godowns with different flooring and bedding materials and bags piled to different heights.*—Well-dried kernels of both Peanut and Coromandel varieties were stored on different flooring and bedding materials such as coir matting, sand, railway cinders and groundnut shell; and bags were piled to different heights as adopted by the trade and their effect studied. Kernels in the bottom bags stored on bedding material like coir matting, on hard (*pucca*) flooring and railway cinders were found to cake up when stored for appreciably long periods especially when the bags were piled to more than ten bags height. Insect pests were seen to breed in large numbers under coir matting and in groundnut-shell used as bedding. Of the dunnage materials tried, clean sand covered with gunny *purdah* appeared to be the best.

(3) *Effect of relative humidity on moisture content and deterioration of groundnut kernels.*—Freshly harvested and well-dried kernels were stored in atmosphere of different humidity for different periods and the moisture and free fatty acid contents of samples determined at scheduled intervals. The following conclusions are drawn : (1) when groundnut kernels (wholes) are exposed to the atmosphere of varying humidity they react to the outside moisture conditions and either absorb or give up moisture and reach hygroscopic equilibrium. (2) Irrespective of the initial moisture content, the percentage of moisture present in the groundnut kernels in hygroscopic equilibrium is essentially a function of the relative humidity of the atmosphere. Thus with 30 per cent relative humidity, the kernels attain hygroscopic equilibrium at 4·5 per cent moisture content, 5·5 with 40 per cent, 8·2 with 70 per cent and 15 per cent with 90 per cent relative humidity. These data will enable one to forecast the probable behaviour of a sample, the moisture percentage of which is known under a particular set of atmospheric conditions. (3) The rate of increase of free fatty acids in groundnuts under storage was definitely greater in samples having a higher moisture content at the time of storage than in a well-dried sample with lower moisture content. The difference in the rate of increase in acidity was marked even though the partially dried kernels gave up moisture when stored under dry

conditions and attained hygroscopic equilibrium. However, the magnitude of increase in the rate of development of free fatty acids is influenced by the outside atmospheric humidity and is directly proportionate to it.

Oil content in groundnut varieties.—Since oil content is the most important commercial character in oilseeds, this was always a major consideration in the evolution of strains. It had to be ascertained at every stage of yield trials that the cultures under-trials were satisfactory in respect of oil content. Extensive investigations carried out showed that the average oil content of South Indian groundnuts is about 50 per cent by chemical extraction and that this character is considerably influenced by seasonal conditions. Varieties showing consistently high percentage of oil were spotted out. One variety *Arachis nambyquarae* was found to give comparatively low oil content of, about 45 per cent and appeared suitable for popularization as a dessert nut.

Specific gravity and oil content.—With the object of finding out whether varieties of groundnut differ in specific gravity and whether it is correlated with oil content, a study was conducted with materials derived from widely different sources. It was found that the specific gravity is affected only very little by the soil and climatic differences. None of the three characteristics, viz., weight of kernels, volume and specific gravity was found correlated with the percentage of oil in the kernels. If high correlation has been established this would have offered to the breeder a rough and ready method for finding out the oil percentage in places where the necessary laboratory facilities are lacking for estimation of oil.

Season and quality.—The oil content which is a varietal character is also found to be fluctuating even up to seven per cent from season to season. Free fatty acids content of kernels is not a varietal character but is solely dependent upon seasonal condition prevailing at the time of harvest and subsequent handling of the produce.

Free fatty acids.—The high content of free fatty acids content of South Indian groundnuts shipped to foreign countries has been estimated to result in considerable financial loss to the State. The causes were investigated and found to be due to (*a*) harvesting the crop when it is not fully mature; (*b*) improper drying of the produce before storing; (*c*) damping or wetting the produce before shelling or decorticating, and (*d*) high percentage of damaged kernels, "hooks" (small pieces) and splits.

Oil crushing industry.—There has been a large expansion in the number of expellers and rotaries in the Madras State as can be seen from the following :—

	Number in.		
	1935.	1945-46.	1948.
Expellers	152 }	1,271	{ 1,227
Rotaries	169 }		{ 2,456
Chekkus	2,5128	31,087	32,889

The capacity of the industry has expanded markedly, so that it can utilize all the oil seeds produced in the State. In the future programme exports as oil instead of kernels, will serve the best interest of the country. The Vanaspati industry in the State is also taking in large quantities of groundnut. There are now eight factories in Madras with a capacity of 25,400 tons of kernels each and three with a capacity of 14,200 tons of kernels each or a total of 144,200 tons of kernels or roughly 57,000 tons of oil.

Grade standards for marketing.—At the instance of the Agricultural Marketing Adviser to the Government of India over 1,000 market samples of groundnuts collected from all over India were analysed in detail for a number of physical factors and also for oil and free fatty acid contents. The results were of much value for the marketing staff to draw up grade standards in groundnut. Specifications for the following commercial grades have been fixed. (*a*) Khandesh, (*b*) Bold, (*c*) Coromandel and (*d*) Red Natal.

Dietetic and nutritive value.—Analysis of groundnut kernels and of groundnut cake, carried out by the Government Agricultural Chemist, Coimbatore, show the nutritive value of groundnut, and cake high; and the protein of groundnut cake is the cheapest of all cake proteins. The haulms also are used as cattle feed.

Part played by research stations.—Even before the creation of a separate section for work on oil seeds, groundnut was receiving certain amount of attention in the District Farm at Pallakuppam, near Tindivanam under the Deputy Director of Agriculture. The work that was carried out was of a preliminary nature. With the inception of the Oilseeds Section, this station passed on to the control of the Oilseeds Specialist. Since 1935, the work is being done at the Agricultural Research Station, Tindivanam, opened exclusively for oilseed work. All the items of applied research enumerated above and fundamental work (given below) on groundnut were carried out at the Agricultural Research Station, Tindivanam.

At Coimbatore which is the headquarters of the Oilseeds Specialist, there was no farm attached to the section. The research work at Coimbatore consists mostly of a chemical and fundamental nature in the laboratory.

Developmental studies—(1) *Root studies.*—The short duration bunch varieties do not have so well-developed a root system as the long duration spreading varieties. The medium duration " semi-spreading " variety AH 73 " Native Tanganyika " is intermediate between the above two types in this respect. The development of the root system more or less seems to be directly related to the yield ing capacity and the bunch varieties are poorer yielders than the spreading varieties. Further among the bunches AH 32 with a better root system is a better yielder than AH 45; and among the spreading AH 25 is superior to AH 1 in respect of root system as well as yield.

It can, however, be stated that the converse is not always true because AH 784 (*Var. gigantea*) and *Arachis nambyquarae* are

poor yielders, even though they have quite a good root system. Similarly, though the drought resistant nature is closely associated with a well-developed root system, the converse is not also true. It is interesting to note that AH. 1728 " Kurumani " (the indigenous variety) a poor yielder with very long duration has well-spread but shallow root system.

Maximum root development is seen within 15 cm. of the soil. Hence the necessity of giving good tilth to the first six inches of the soil before sowing groundnut is quite evident. Deep cultivation is not necessary for the crop. The period of maximum development of the root system is during the second month and it almost synchronises with the period of maximum shoot development. For the proper development of groundnut plants and to obtain high yield it is, therefore, necessary that there should be adequate and properly distributed rainfall during this period.

(2) *Shoot development.*—The growth is greatly influenced by rains. A well-distributed south-west monsoon is essential for good plant growth. The short duration bunch varieties suffer most in the absence of early rains, while the long duration spreading types revive if the north-east monsoon rains are received in time. Absence of north-east monsoon showers arrests growth of plants in the later stages with the result that the spreading types get no benefit from their longer duration. The count of total number of nodes or leaves is generally low in the non-branching bunch types, and high in the spreading types. It is interesting to note that AH 45 among the bunch types and AH 1 among the spreading types have the least resistance to drought as is seen by their quick fall in growth rate in the absence of rains. However, AH 25 (Saloum) a high yielding, partially drought resistant variety is seen to have the poorest shoot development among the spreading types.

(3) *Flowering.*—Flower production in the groundnut as in shoot development is profoundly influenced by rainfall. A well-distributed rainfall is more beneficial than heavy rains received at irregular intervals. In the bunch types flower production starts about the 24th day and continues for a month. In favourable seasons, a second feeble flush is also observed. In the spreading varieties there are distinct waves, the first starting from the 28th day and lasting for a month and the second wave of about a month's duration starting after a break of fortnight. If the south-west monsoon is defective flower production is late and feeble in the earlier stages and the two waves of flower production in the spreading types may merge into one. If the north-east monsoon fails, the second wave may be feeble or absent. The flowering in the bunch types is seen to rise sharply, while it is spread out in the spreading types. In the other types, flowering is heavy and profuse and continues for a much longer period with marked decrease during periods of deficient rainfall. The varieties and forms studied have been divided into seven distinct groups.

(4) *Fruiting.*—The fruiting phase in the groundnut is again largely dependent upon the seasonal rainfall. A well-distributed rainfall in the early stages is necessary for good flower production. For good setting bright sun shine is essential. The fertilized pegs require sufficient soil moisture for growth and subsequent development underground. These climatic conditions seem to be contradictory. But in reality, the season obtaining at the end of the south-west monsoon and during the beginning of the north-east monsoon is characterized by alternate spells of dry and wet weather. As the early plant growth and the first flush of flowering is over by south-west monsoon period, the alternate dry and wet periods are ideal for the fruiting phase. To get this benefit it is necessary that the sowings are done early in the season. Observations over a number of years have shown that early sowings result in high yields.

The study has given an idea of the development of certain groundnut varieties and forms. The characteristic differences among them in respect of growth, flowering and fruiting behaviour are marked. The influence of rainfall and its distribution on every phase of development is considerable.

(5) *Development of the gynophore (or stalk of pod) in artificial media.*—The development of the tip of the gynophore into pod in artificial media like sand, powdered charcoal, cotton wool, loose saw dust, air, etc., was studied. Pods were found to develop normally in sand and powdered charcoal irrespective of the media being moist or dry. In the other media no development took place indicating the probable necessity for some resistance on the part of the media to encourage pod development.

(6) *One to three kernelled nature of pods.*—The production of 1, 2 or 3 kernelled pods on a plant of a variety having generally one to three kernelled pods is found to be independent either of the position of the flower on the plant or the time of appearance of flowers. Plants raised from seed obtained from 1, 2 or 3 kernelled pods did not breed true or give a high preponderance of the particular kind of pod showing thereby that selection of 2 or 3 seeded pods for seed purposes is unnecessary.

(7) *Seed dormancy.*—This is an important economic character in the groundnut as seeds of non-dormant types on receipt of rains at harvest time sprout in the field, causing considerable loss of produce as in Pollachi and Guntur tracts where bunch varieties (Spanish, Small Japan, etc.) are cultivated. Dormancy studies show that the bunch varieties have generally non-dormant seeds, while the spreading varieties have dormant seeds. Based on these studies hybridization has been done to produce a bunch type with dormant seeds.

It is also found that the bunch varieties can be used for seed purpose about ten days after harvest, as about 90 per cent of the seeds germinate after a week's drying. In the spreading

varieties, the seeds can be used for sowing only about 2½ months after harvest as these require a resting period of about 2½ months.

(8) *Seed viability.*—Viability studies have shown that groundnuts remain viable for about four years if the seeds are kept in air-tight containers. They lose viability in about a year if stored under ordinary conditions, in gunny bags.

Physiological investigations.—To elucidate the physiological basis for the differences in yield of various strains one particular aspect, viz., the economy in the utilization of water was investigated in respect of the varieties, viz., "Gudiyatham Bunch", "Saloum" and "Local Mauritius". The production of dry matter was found to be the highest in "Saloum" as compared with "Local Mauritius" and "Gudiyatham Bunch". The leaf surface per plant was also the greatest in "Saloum". In the early stages of growth the percentage of moisture was the least in "Saloum", but in the economy of utilization of water "Saloum" is better than "Gudiyatham Bunch". To produce "Saloum" is better than "Gnidyatham Bunch". To produce a gramme of dry matter about 1,010 grammes of water was required in "Gudiyatham bunch" as against 85 grams in "Saloum".

Wilting co-efficients were also worked out for red and black soils. They varied from 5·9 to 6·3 in the case of red soil and from 9·7 to 10·3 in the case of black soil.

Anatomical studies.—A detailed study of the anatomy of the different parts of the groundnut plant was made. The studies have shown that the groundnut plant is a mesophyte with xerophytic adaptations. But as in water plants normal root hairs are absent and their function is taken up by a mucilage tissue outside the cortex of the absorbing region.

The origin of the lower epidermis of the leaf is different from that of the upper. The former is derived from the dermatogen while the latter is from the periblem of the leaf primordium.

The structure of the developing peg (pod stalk) is essentially that of the stem which is always negatively geotropic. But the pegs exhibit positive geotropism and enter the soil. To explain this behaviour the hypothesis was advanced that it might be due to the presence of a large number of minute bodies (plastids) developed after fertilisation in the epidermal cells of the gynophore. Plastids were few in abnormal pegs that grew away from the soil. The shell of the developing pod was found to act as an organ for storing starch and oil in the early stages.

Genetic characters.—The inheritance of the following characters has been determined :—

Character.	Factorial constitution.
Bunch habit	$s_1s_1\ S_2S_2$ TT.
Spreading habit	$S_1S_1\ S_2S_2$ tt.
Trailing habit	$S_1S_1\ s_2s_2$ TT.
Branching habit	BB.

Character.	Factorial constitution.
Chlorophyll deficiency	$g_1g_1\ g_2g_2$.
Abnormality	$n_1n_1\ n_2n_2$.
Early duration	l l.
Sparsely hairy	h h.
Purple colour in the plant	$R_1R_1\ R_2R_2$.
Green colour in the plant	$r_1r_1\ r_2r_2$.
Rose colour of the testa	R_1 or R_2.
Red colour of the testa	Rd Rd.
Purple colour of the testa	PP.
White colour of the testa	$r_1\ r_2$rd P.
Crescent on the petal	CC.

Linkage with 30 per cent crossing over has been observed between habit and branching.

Correlation studies.—A positive and significant correlation between the ratio of the average length of the primaries (branches) to the height of the main axis and the weight of pods was found to exist in the groundnuts.

Cytological investigations.—A detailed cytological study, particularly of the somatic chromosome morphology of 15 groundnut varieties and forms exhibiting differences in morphological characters was made. The study involved a critical scrutiny of the morphology of individual chromosomes in the metaphase complement and a survey of the number of nucleoli organised at telophase and a careful examination of the number and morphology of the chromosome attached to the nucleolus at prophase. The meiotic behaviour of the pollen mother cells was also made. The study has shown almost conclusively that both the bunch and the spreading varieties have all had a common origin thus disapproving the theory of dual origin held by some other workers. It was also shown that *Arachis nambyquarae* and *A. rasteiro* now classified as species district from A. *hypogæa* cannot be accorded such a status but can be considered at best as only sub-species or varieties of *A. hypogæa.*

The causes for the appearance of abnormal plants in F_2 progenies of crosses involving a form called ' corrientes ' as one of the parents were also investigated. It was found that the second division is absent occasionally in the pollen mother cells in ' corrientes.' This phenomenon was prevalent to an extraordinary degree in the abnormal F_2 plants indicating the probable recessive nature of the factor for the absence of second division in the pollen mother cells.

Conclusion.—Since 1930, research on the groundnut has been in progress at the Agricultural Research Institute, Coimbatore, and at the Agricultural Research Station, Tindivanam in the South Arcot district. The work is directed towards " the collection and testing of large number of varieties and isolation of single plants having various economic characters such as high yield, high oil content, high shelling outturn (kernel to pod ratio) and drought resistance. As a result improved strains have been evolved and these are becoming popular. Though the strains evolved at Tindivanam

have given more than 25 per cent increased yields over the local variety in the southern and central districts of the State they have not been found suitable for the black soil tracts of the Ceded districts or the Circars. The Pollachi tract where the groundnut is cultivated earlier than in other areas require special types of dormant strains which have to be evolved specially for the tract.

Intensive breeding work to evolve types resistant to disease and drought, combining high yield of seed and oil have to be undertaken and the manurial requirements of the crop as also the important agronomic aspects of the crop have to be studied and determined. More seed multiplication and distribution centres have to be started to speed up the seed distribution work and to cover the maximum area with the improved strains in as short a time as possible.

GINGELLY.—(*Sesamum indicum* linn.)

(Family—*Pedaliaceae*; Tamil—*Ellu*; Telugu—*Nuvvulu*; Malayalam—*Ellu*; Kannada—*Yallu*; Hindi—*Til*.)

Production and importance.—The sesame or gingelly (Til) occupies roughly about four million acres in the Indian Union. The annual production is estimated at 4·2 lakhs of tons of seed. The Madras State has 17·7 per cent of the area and 20·7 per cent of the production. This is second to Uttar Pradesh which has 33·6 per cent of area and 31·6 per cent of production.

The normal production in Madras is estimated at 80,000 tons of seed. The Circars comprising the districts of Visakhapatnam, East and West Godavari, Krishna and Guntur is the most important area for gingelly accounting for as much as 50 per cent of the acreage in the State. The district of Visakhapatnam alone has over a 1·3 lakhs of acres of gingelly.

A perusal of the figures for the area under the crop in the State during the past 14 years shows considerable variation from year to year, the trend being definitely downward. The area and production of gingelly seeds in Madras during the last 14 years ending 1948–49 were as follows:—

Year.	Area in thousands of acres.	Production in thousands of tons.
1935–36	750	86
1936–37	802	100
1937–38	795	77
1938–39	876	94
1939–40	734	90
1940–41	786	103
1941–42	693	84
1942–43	840	98
1943–44	697	81
1944–45	616	76
1945–46	599	67
1946–47	673	79
1947–48	[illegible]	72
1948–49	652	[illegible]

The area under gingelly which ranged from 7·5 to 8·5 lakhs of acres in the pre-war period, fell to six lakhs of acres by 1944–45 and is now of the order of 6·5 lakhs of acres. This is not surprising in view of the fact that out of 6·5 lakhs of acres in the State, one lakh of acres alone is raised under irrigated conditions, guaranteeing a sure crop. The remaining area is sown under unirrigated conditions and the area sown therefore varies depending considerably on the receipt of rains at the sowing time. Due to unfavourable seasonal conditions for a series of years the crop might have been given up in some tracts in favour of surer crops.

Export and import.—Gingelly is the source of much valued oil and cake. The oil is very widely used for edible and domestic purposes while the oil-cake is a prized cattle-food. The seed is also used in household preparations.

The entire production in India is consumed in the country itself, only very negligible quantities being exported. That an overseas market can be created for the commodity is beyond doubt. In fact, prior to World War I, India was exporting gingelly seeds to the tune of about one lakh of tons. Since the internal consumption has increased much, without any corresponding increase in production, the export has now practically ceased.

Gingelly seed is in short supply in Madras State and therefore large quantities amounting to 20,000 tons are usually imported from Orissa, Hyderabad and Uttar Pradesh every year.

Scope for development.—There is scope of increasing the area by 75 per cent if the conditions are favourable. The Panel on Oils and Soaps has recommended an increased production of 600,000 tons per annum, out of which 500,000 tons will be for oil extraction. Improved strains giving about 20 to 25 per cent increased yield over the local varieties have been evolved in the oil-seeds section of the Madras Department of Agriculture. If these were to replace the local varieties, the present production can be substantially increased. Since gingelly is a season and tract bound crop, suitable strains for different tracts have to be evolved at separate Regional Research Stations which have to be established.

Cultivation in general.—Sesamum is raised during three different seasons in the year in different localities. It is grown under rain-fed conditions from June to October and again from November to January in certain tracts. As an irrigated crop it is raised from March to July.

Under irrigation it is mostly raised as a pure crop during the summer season, while the rain-fed crop is usually sown mixed with other crops. In parts of Visakhapatnam and Tirunelveli, it is sown in wet lands, after the harvest of rice.

Varietal introductions and trials.—The varieties of sesamum cultivated in different parts of the State vary in their duration and in the colour of seed. It is also found that a variety grown in a

particular tract or a particular season is not generally suitable for other tracts or seasons except in rare cases.

A collection of a number of varieties from different parts of the world was grown at Tindivanam both during summer and cold weather to judge their suitability to these seasons. As a result of this study, the varieties were grouped into hot weather and cold weather varieties. At present 105 ' varieties ' suited for summer cropping and 20 ' varieties ' suited for cold weather cropping are maintained. Out of these, pure line cultures showing distinct characters have been isolated and are being maintained pure to serve as basic material for breeding work.

Evolution of strains by selection—TMV 1 (*S*.1.89).—This is a mass selection from ' Palni ' variety. The plants are fairly bushy with moderate branching. Capsules are medium sized, one in an axil four loculed and closely set on the stem. Seeds are medium sized and vary in colour from red brown to black. It has given very good yields in the district trials conducted in South Arcot, North Arcot, Tanjore, Tiruchirappalli, Nellore, Coimbatore and Malabar. The maximum yield recorded per acre was about 950 lb.

Season: can be grown as a rain-fed or an irrigated crop.

Duration: 85 days.

Average acre yield: 500 lb. as an irrigated crop; 200 lb. under rain-fed conditions.

Percentage increase on local: 33.

Weight of 1 MM of seeds: 2 lb., $11\frac{3}{4}$ oz.

Oil content: 50 per cent

By hybridization—TMV 2 (*Cross* 6).—This is a selection from a cross between " Nagpur white " and " Sattur ". It is most suitable for cold weather cropping in December to March. Plants have moderate branching, capsules big sized, one in an axil, six to eight loculed with moderate setting; seeds are large and of dull white colour. The strain combines early duration, high oil content, lighter colour of seeds. It has the additional advantage of partial splitting of capsules which prevents shattering of seeds at maturity.

Average acre yield: 375 lb. under rain-fed conditions (cold weather):

Percentage increase over local: 86.

Duration: 80 days.

Weight of 1 MM of seeds: 2 lb., 10 oz.

Oil content: 52 per cent.

TMV 3 (*Cross* 38).—This is another high yielding strain evolved by cross-breeding between the local gingelly of Tindivanam and the Malabar wild gingelly. It is suitable for growing as an irrigated crop in summer and has given about 50 per cent increase in yield over the local variety. It is more resistant to wilt and shoot-webber attack than the local. The resistant nature has probably been inherited from the wild parent. It contains about

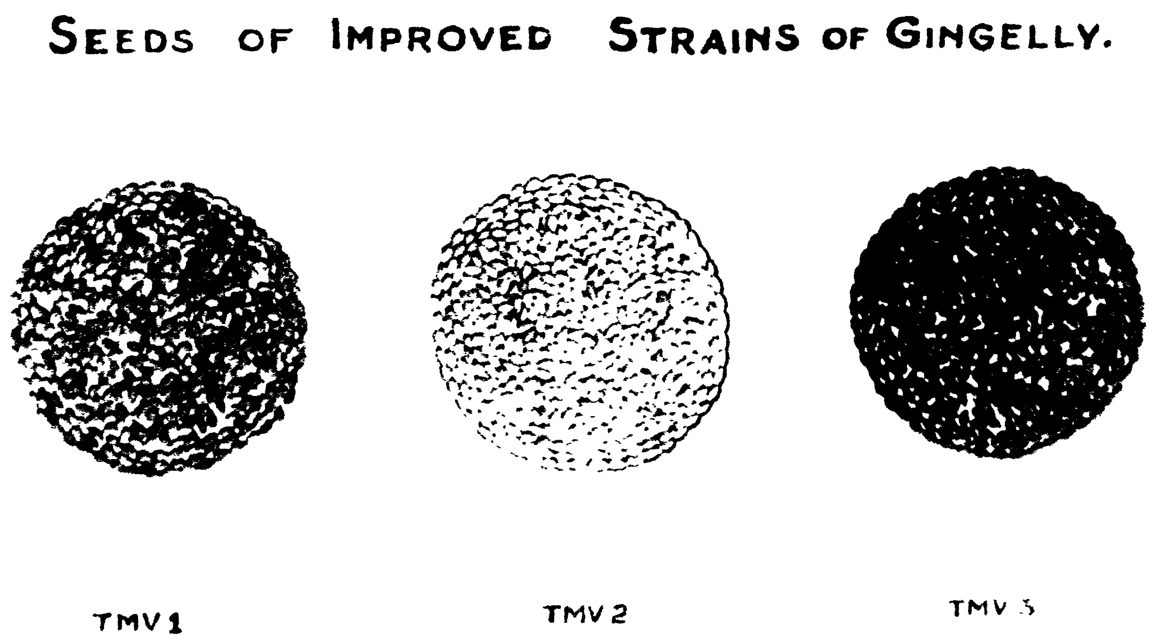

Plate 32.—Seeds of improved strains of gingelly.

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two per cent more oil than the local variety and is also earlier in duration.

Average yield per acre (irrigated) : 550 lb.
Percentage increase over local : 53.
Duration : 80 days.
Weight of 1 MM of seeds : 2 lb. 11 oz.
Oil content : 52 per cent.

Further hybridization work.—Gingelly being a season bound crop, a number of 'varieties' have been crossed to evolve cosmopolitan types. The progenies of these crosses are under study. A number of inter-specific crosses between *Sesamum orientale* and *S. prostratum* were attempted; the hybrid of the cross was found to be completely sterile. Attempts to induce fertility by the duplication of chromosomes by colchicine treatment did not prove quite successful.

Agronomic trials—Economic spacing.—Spacing has been observed to influence markedly the development of the gingelly plant. To determine the economic spacing to be adopted for the gingelly crop grown under rain-fed conditions during cold weather and under irrigation during summer, trials were started from 1948 winter and summer with five spacings, namely, 6 inches by 6 inches, 9 inches by 9 inches, 1 foot by 1 foot, 1½ feet by 1½ feet and 2 feet by 2 feet. Wider spacing reduced plant height and increased branching, flower production, capsule size and capsule number, but prolonged the duration. Spacings 9 inches by 9 inches for winter crop and 1 foot by 1 foot for summer crop have given maximum yield per unit area in the respective seasons.

Storage of gingelly seeds and deterioration.—The deterioration of three types of gingelly seeds (well dried), viz., white, red, brown and black was studied for about a year. There was only slight deterioration on storage. It was comparatively low in the white gingelly seeds. Provided sufficient precautions are taken against insect pests, well dried gingelly seeds can be stored for a fairly long time without much deterioration.

Part played by research stations.—Research on sesamum also is being done at the Groundnut Research Station, Tindivanam. Three strains were evolved of which one TMV 1 is a selection and the other two TMV 2 and TMV 3 are derived from artificial crosses. These strains have given about 20 to 30 per cent increased yield over the local 'varieties' in the southern and central districts where they have been tried. Trials with different spacings and storage of seeds have been carried out. Results of considerable practical importance to the ryots have been obtained and passed on for adoption.

Fundamental work.—(1) *Flowering and fruiting studies.*—The floral structure and anthesis were studied in all the typical 'varieties' as a preliminary to cross-breeding work and efficient technique

for selfing and crossing has been evolved. Flowering in gingelly is seen to start a month after sowing and the capsules take 30 to 40 days to attain maturity.

(2) *Study of oil formation in gingelly.*—The course of oil formation in gingelly was studied to determine the optimum stage at which the capsules would become ready for harvest. It was found that oil formation starts from about ten days after the opening of flowers and increases to the maximum in about 30 days, i.e., about a fortnight prior to the complete drying up of the capsules. There is also reduction in the free fatty acids and moisture contents of the seeds as the oil develops and reaches the maximum. Seeds from capsules at this stage of development are also found to give normal germination. Gingelly could, therefore, be harvested when the plant shows first signs of yellowing without the necessity to wait till the capsules are dead ripe. Such harvest will prevent loss due to shattering of seeds of the produce.

(3) *Oil content of 'varieties' and cultures.*—Studies on the oil content showed that 'varieties' from Palestine, Burma and certain other countries which are reputed for high oil content turned out to be only as good as the local 'varieties'. A wild gingelly variety from Malabar was found to contain only about 32 per cent of oil. In a cross in which this was used as a parent, because of its certain other desirable characters it possessed, special care had to be taken at every stage to see that the ultimate selection did not inherit the character of low oil content of the wild gingelly parent. In gingelly the average oil content was found to be about 50 per cent by chemical extraction. Strains TMV 2 and TMV 3 now being distributed possess about 2 per cent more oil than the local 'varieties'.

(4) *Deterioration of gingelly oil in storage.*—When stored in tins, gingelly oil retained its colour and flavour for a period of about six months. Later on it got lighter in colour and began to smell rancid. The trend of deterioration was almost the same in the oils from white, black and red gingelly seeds.

(5) *The effect of adding water or jaggery on the extraction of oil.*—While crushing gingelly seed in wooden chekkus and rotary mills, it is a usual practice to add some binding substance like jaggery, gum arabic, water, etc. The necessity for the binders and the deterioration of oil expressed by the addition of these were studied. It was found that in the absence of jaggery and water, the oil did not separate and flow freely. The following percentages of extraction were obtained:—

	PER CENT.
Jaggery alone	43·8
Water alone	39·2
Jaggery and water	42·2

It was demonstrated conclusively that the addition of such binders was necessary to get satisfactory extraction.

The progress of deterioration of the oil obtained by the three methods was investigated. It was seen that deterioration was very marked in the oil obtained by the addition of water alone and was least in the oil obtained by the addition of jaggery alone. Rancid smell developed much quicker in the oil extracted with water alone than in the other two. Another interesting observation made was that where water was added the oil turned distinctly deeper in tint as the period of storage progressed.

(6) *Inheritance studies.*—The factorial constitution of a number of characters in gingelly was determined from inheritance studies carried out on the crop. They are summarised as follows :—

Purple corolla	CC
Purple pigment on the anthers	CC PP
Colour at the base of the style	Cs Cs
Solitary flowers in the axil	SS
Four loculed nature of capsules	LL
Bushy habit	BB
Black seed coat colour	Bl Bl

(7) *Cytological studies.*—Chromosome numbers of gingelly varieties were determined and found to be n=13 and 2n=26. The chromosome numbers of a gingelly variety growing wild in parts of Travancore, Malabar and South Kanara and which exhibited characters different from the ordinary cultivated gingelly varieties were also determined and found to be the same as those of the cultivated gingelly varieties. The chromosome numbers of the species *S. radiatum* obtained from Africa for breeding purposes were determined for the first time as 2n=64.

Conclusion.—The work so far done in gingelly, like that on groundnut, was done at the Agricultural Research Station, Tindivanam. Three improved strains with 20 to 30 per cent increased yields have been evolved. Though these strains are doing well in southern and central districts, they are not suited to north-eastern districts of the State, viz., Visakhapatnam, East and West Godavari and other places where conditions are different from those prevailing at Tindivanam. Except spacing experiments, no agronomic work on the aspects such as manuring, rotation, mixed cropping, etc., has been attempted. There is scope for more work both on economic and fundamental aspects of this crop. Nucleus seed multiplication centres have to be organized for quick spread of the improved strains.

CASTOR (*Ricinus communis*) *Family—Euphorbiaceae.*

(Tamil—*Amanakku*; Telugu—*Amudalu*; Malayalam—*Aavanakku*; Kannada—*Haralu*; Hindi—*Arandi.*)

Production and importance.—The castor crop in Madras occupies an area of about 2·6 lakhs of acres. This is 18 per cent of the total area under castor in the Indian Union. Hyderabad occupies the foremost place with 54 per cent of the area and 48 per

cent of the production in the Indian Union. The average annual production in Madras is about 20,000 tons and this forms 17 per cent of the total production in the Indian Union. The important districts where castor is cultivated are Anantapur, Nellore, Kurnool, Guntur, Bellary and Salem.

In recent years there has been a gradual decline in the area under castor. The area fluctuates in relation to demand, price and seasonal conditions. The crop is generally grown in inferior land not fit for other valuable food or commercial crops. The ryots also do not like to raise castor in large areas as it remains in the field for seven or eight months and is liable to complete destruction by the semilooper caterpillar pest.

Exports and imports—

Year.	Exports of castor seed in 000 tons. By sea to foreign countries.	Exports of castor seed in 000 tons. By rail to other States.	Imports by rail from other provinces 000 tons.
Average for 1937–38 to 1941–42 ..	15·1	0·6	6·4
1942–43	9·8	6·0	3·6
1943–44	4·9	3·8	6·2
1944–45	0·8	2·9	1·7
1945–46	2·2	4·0	1·3
1946–47	0·7	3·3	4 7
1947–48	..	2·6	2·5

In pre-war years about 50 per cent of the production used to be exported. Of late, Brazil has become a serious competitor with India in International trade.

Scope for development.—It is possible to increase the production of castor seeds in this State by the popularization of improved strains, evolved by the department. These give 20 to 25 per cent increased yield over the local varieties and have done well in some of the important castor-growing districts of the State. As the castor crop is only of secondary importance to ryots, it is not likely that they will devote any larger area to the crop. But the yield from the existing area can be increased if cheap and effective control measures against the most destructive pests of castor, *viz.*, castor semilooper are found out.

Environmental factors and their influence on cultivation.—The castor crop is generally cultivated under rainfed conditions from June to February in the dry lands. It is also raised as a garden crop under irrigation, there being no particular season for sowing the crop. Trials at the different stations in the Nilgiris have given valuable information about the influence of elevation, temperature and season on castor cultivation.

Trials in Nilgiris.—With a view to stimulating castor cultivation in the Nilgiris, seven high-yielding castor strains isolated from the annual types of the plains and from four perennial types

Plate 33.—*Strains of Castor.* *A—TMV.* 1. P. 242

collected from Nanjanad. Coonoor, Gudalur of the Nilgiris, and Anamalais were tried at the Agricultural Research Station, Nanjanad, Botanical Gardens, Ootacamund and Pomological Stations, Coonoor and Kallar for a comparative study. These were sown in two seasons, viz., March–April and September–October in conformity with the two normal sowing times in the Nilgiris. The following general conclusions were drawn from these trials :—

(1) Of the two seasons, September–October is not suited for the sowing of either the annual or the perennial varieties of castor on the Nilgiris. At higher elevations the intense cold and the intermittent frosts of the winter months, and in the lower heights the absence of sufficient rains during the period of growth are the causes contributing to the failure of the crop during the season.

(2) The sowing in March–April commencing with the receipt of the first rains seems best suited for the castor crop. Early sowing is very necessary to enable the plants to establish themselves before the heavy monsoon rains set in.

(3) The annual varieties as well as the perennials can be raised successfully only up to an elevation of about 4,000 feet above sea level. The perennial types, however, grow fairly well under cultivation at elevations above 4,000 feet also.

Varieties cultivated.—In the Madras State, both annual and perennial varieties are found; but only the annual varieties are cultivated on a field scale. The perennial types are found wild in Nilgiris, Anamalais and Mitranpatty Hills. An extensive study of these varieties has shown that the perennial Nilgiri types are poor yielders and have a low oil content of about 48 per cent. The perennial Anamalai variety is a high yielder and has a high oil content of 56 per cent.

Strains evolved by selection—Co 1.—This is the " Anamalai perennial ", a selection from the perennial varieties. It is a high yielder with very bold seeds (28 seeds for an oz.) and an oil content of 56 per cent. It does well both in plains and in high elevations up to even 7,000 feet. There is considerable demand for this strain from coffee and tea estate for growing as a shade crop.

TMV 3. (*R.C.* 215).—This is a selection from a South Arcot variety; it gives an increased yield of 27 per cent over the local. The capsules mature uniformly on the inflorescence. This is the best suited for sowing as a border for garden land crops like sugarcane, turmeric, chillies, cotton, etc.

Duration: Eight months when sown as a rainfed crop.
Average yield : 750 lb.
Increased yield over local : 27 per cent.
Number of beans per lb. : 1,410.
Weight of one Madras measure of beans : 2 lb. 6¼ oz.
Oil content : 55 per cent.

By Hybridization—TMV 1 (*R.C.* 59-8-1)—(*Plate* 33).—This is a high yielding strain evolved from a cross between two inbred

types "Namakkal irrigated" and "Hospet". It is found to combine the length of the inflorescence of the former with the branching habit and loose setting of capsules of the latter. It is suitable for cultivation as a rainfed crop. Trials have also shown that it is suited for Ceded districts where it has recorded even 80 per cent increase in yield over the local variety which is an eight months crop.

Duration as rainfed crop : 6½ months.

Average acre yield : 750 lb.

Increased yield over local (average) : 17 per cent.

Number of seeds per lb. : 1,880.

Weight of 1 Madras measure of beans : 2 lb. 7½ oz.

Oil content : 51 per cent.

TMV 2 (*R.C.* 59-2-1-1).—(Plate 34). This is another strain evolved from the same cross between "Namakkal irrigated" and "Hospet". It is medium in duration and is suited for cultivation as a rainfed crop. Capsules are non-dehiscent and can remain dry on the plant for several days after maturity without shedding the seeds. It is best suited for Salem district where it has given 28 per cent increased yield over the local.

Duration as a rainfed crop : Seven months.
Average acre yield : 775 lb.
Increased yield over local : 21 per cent.
Number of kernels per lb. : 1,560.
Weight of one Madras measure of beans : 2 lb. 6 oz.
Oil content : 50 per cent.

Other hybridization work.—Extensive hybridization work has been taken on hand for the purpose of reducing the duration still further and also to impart distinct colours to the strains for easy identification in cultivators' lands. A large number of progenies having the desirable combination of characters has been obtained and they are under different stages of trial.

Agronomic trials—Spacing trials.—Trials carried out to determine the economic spacing for a pure crop of castor of medium duration have shown that three feet spacing either way is the best. Closer spacings have been found to increase plant height and duration, delay flowering, and reduce branching, stem thickness, length of inflorescence and number of capsules.

Harvesting and yields.—An experiment was conducted to find out the effect on oil content, free fatty acids and germination of castor seeds when fruit heads are harvested and subsequently stored and dried by different methods which are commonly practised by the ryots. Harvesting castor heads when one or two capsules showed signs of drying and heaping them for a week as is practised by the ryots of certain districts have been proved to be highly detrimental to the quality of the produce. Experiments

Plate 34.—Strains of Castor. B—T.M.1. 2.

Plate 35.—*Strains of Castor C—T.M.V.* 3.   P. 246

have shown that oil content gets reduced by two to three per cent and free fatty acids increase considerably by heaping and allowing the capsules to ferment. The best practice is to harvest fully mature heads and dry them immediately after harvest.

The local varieties of castor give on an average about 600 lb. of seeds under rainfed conditions. The improved strains give higher yields ranging from 17 to 28 per cent over the local. In TMV 1, even 80 per cent increased yield over the local has been obtained in the trials at Ceded districts. TMV 2, has given an acre yield of 1,000 lb. under favourable conditions.

Storage studies.—Periodical estimation of oil and free fatty acids of castor seeds stored in gunny bags under ordinary conditions, showed that the seeds remained without any marked deterioration for over three years. They also remained free from any insect attack.

Part played by Research Stations.—Research work on castor was done at the Agricultural Research Station, Tindivanam along with work on groundnut and sesamum. The work was directed towards the evolution of strains combining high yield, high oil content and short duration, both by selection and by breeding. Improved strains as TMV 1, TMV 2, and TMV 3, (Plate 35) have been evolved. At Coimbatore from among the perennial types, " Anamalai perennial " a strain CO 1 has been selected for its heavy yields and high oil content.

Spacing trials to fix up the optimum spacing, and harvesting trials to find the best method of harvest have been carried out, as already stated. The other items of research work done on the crop are the following :—

Fundamental work—(1) *Root studies.*—With the object of tracing the root development in castor, three types representing short, medium and long durations strains were studied for their root development. The study has revealed that the castor plant has a well-developed root system going to a depth of six feet and more and has numerous long primaries and secondaries occupying the region just below the ground level intertwining and forming a thick matting. There seems to be direct relationship between duration and root development. High rate of development takes place earlier in the short duration type, while in the medium and long duration types, this phase of development occurs later. The long duration types have longer primary laterals and greater penetration into the soil.

(2) *Growth studies.*—The study of development in growth in castor plants was made with types having varying characters. The observations showed that castor plants grow rapidly in height and thickness, until the appearance of the main inflorescence and the rate of development is then slowed and comes almost to a stand still with the ripening of the capsules on the terminal inflorescence. Further growth is observed only in the branches which in their

turn cease to grow when the capsules on the inflorescence terminating them become mature. With the cessation of the production phase, further growth ceases and actually a certain amount of shrinkage in the thickness of the stem takes place. This kind of development is common to all types of castor but only the periods of the different phases of development vary according to duration. The height and thickness of the long duration types increase even a fortnight or a month after the short duration types cease to show this increase. Similar delay is observed in the production of fruit clusters. The total number of nodes up to the first inflorescence is definitely large in the medium and long duration types, thus showing that the character is a clear indication of the duration. The interval between the ripening of the capsules on the main inflorescence and those of the branches is comparatively more in the longer duration types.

(3) *Defoliation studies.*—Castor leaves are used for eri silk worm feeding. To determine the effect of defoliation on the economic characters of the castor plant and to fix up optimum interval of defoliation that would least affect the plant, a study was carried out. Defoliation decreases plan height and stem thickness, reduces branching and length of inflorescence, delays flowering and brings down the duration. As a result, the yield from the plant is considerably affected. The yield is reduced by 51 per cent in the case of the short duration type and about 74 per cent in the case of the long duration type. Fortnightly defoliation of plants showed 77 per cent reduction in yield while monthly defoliated plants showed 46 per cent reduction in yield. In the latter case the number of leaves removed was less but the weight of leaves was more. From these results, defoliating castor plants for eri silk worm feeding at monthly intervals seems to be desirable.

(4) *Capsule dehiscence.*—In castor, three types of capsules based on their behaviour at maturity are met with, viz., non-dehiscent, dehiscent and proper types. In the non-dehiscent form, the locules separate with difficulty and more labour is required in shelling. In the dehiscent form the locules separate easily but the seeds are not shed. In the popper type, the capsules burst with force at maturity and the seeds are thrown out to a considerable distance. This is a very undesirable character as considerable loss of produce occurs in this type.

The cause of this differential behaviour was elucidated by anatomical studies. It was found to be due to the difference in the general make-up of the interlining tissue of the capsule. In the popper type this tissue consists of large hollow cells which shrink on drying and the stress developed cleave the locules apart with such force that the seeds are thrown out. In the other two types, the particular tissue is much less developed.

(5) *Study of oil formation in castor.*—The study of oil formation in castor showed that the deposition of oil is fairly rapid in the early stages. In three weeks, the seeds contained about 30 per cent of oil, which rose to 48 per cent by the sixth week.

The deposition of oil is continued but less vigorously. As the dry weight of the seed increased, the percentage of oil showed a slight fall.

(6) *Study of the oil content of castor varieties and cultures.*—All the varieties and cultures at the different stages of yield trials were regularly assessed for the oil and free fatty acid contents. Though the percentage of oil ranged to about 50 by chemical extraction, it was found to be influenced considerably from year to year due to climatic conditions. Two strains which have been released from this section, viz., TMV 3 and CO 1, are found to record about four to five per cent more oil than the other varieties.

(7) *Maintenance of inbred types.*—As a high percentage of cross fertilization (5–14 per cent) occurs in nature in this crop, it was found extremely difficult to maintain the varieties in a pure state except by artificial means. To ensure self-fertilization, the inflorescences are covered with close-meshed cloth bags before the flower buds begin to open. The cloth bags are removed when a fairly large number of capsules have resulted from the self-fertilization. The selfed seeds are used for further propagation. By the process of inbreeding, 140 pure types exhibiting all the available variations in the original collection of varieties were isolated and are being maintained from year to year to serve as basic material for selection and breeding work on the crop.

(8) *Maintenance of vigour and purity of strains.*—In castor where the percentage of cross-pollination is fairly high in nature, it is a very difficult problem to obtain large quantity of pure inbred seeds by selfing the inflorescences, as the vigour of the strains goes down in course of time due to inbreeding. With the object of maintaining the vigour and purity of the strains, the following technique has been followed and has been found to work satisfactorily. The three strains are grown in isolated blocks far removed from each other. In each of them, the most outstanding plants are selected. The selections from each strain are compared separately in progeny-wise trials in isolated blocks. The yield data are analysed. The produce of those selections which give more than the general mean are pooled together for being used for further multiplication while the rest are rejected. This process of selection and testing of outstanding types of plants is continued so that the mean value of each strain is always maintained by the elimination of undesirable progenies every time.

(9) *Anatomical studies—Stem structure of annual and perennial varieties of castor.*—Though various workers have made mention of the existence of perennial types of castor as distinct from annual types, no reference is found made regarding the features which would enable the one to be distinguished from the other. In most of the morphological characters such as stem, colour, nature of inflorescence, shape and size of leaf, nature of capsules, size and shape of beans, etc., they resemble one another.

Anatomical studies of the stem of the seedling of annual and perennial types revealed that the structure of the stem of the

perennial type differs from that of the annual cultivated varieties and affords an easy means of distinguishing one from the other. The annual varieties have the characteristic herbaceous stem with limited secondary growth while the stem of the perennial castor has a more or less continuous cylinder of primary xylem ensheathed by an unbroken cylinder of secondary xylem which is added on indefinitely: In the young stem of the same age of the cultivated castor, the vascular tissues are arranged in the form of discrete or discontinuous bundles in a cylinder. The stem of the cultivated type develops to a definite girth when further growth ceases.

(10) *Cytological studies.*—The chromosome numbers of annual types and perennials which exhibit distinct anatomical features were determined. The chromosome numbers were found to be the same in both, viz., 2n = 20.

Conclusion.—Three improved annual strains and one perennial strain have been evolved by the Oil seeds section. The improved annual strains complete their life in seven or eight months, while the local takes nine months. Their yield and oil content are also higher than the local. The district trials have conclusively proved that TMV 1 is suited to Anantapur district and TMV 2, to Salem. These strains have given about 20 per cent increased yield over the local ' varieties '. But no organized multiplication and distribution of seeds of these strains have been attempted. The problems that are yet to be tackled are the following : (1) Evolution of short duration, high yielding strains with high oil content and having desirable characters as drought resistance, non-dehiscent capsules, uniform maturity, smooth capsules and resistance to semi-looper and shoot-borer attack, and (2) determination of optimum, cultural and manurial practices to obtain the maximum yields.

Other oil-seed crops of minor importance to the State.—Niger, safflower, mustard and linseed are considered as minor oil seeds in Madras. These occupy a total area of 64,000 acres. Separate statistics of area are not available for each of the crops except in linseed and mustard which are estimated to occupy about 3,300 acres and 1,900 acres respectively. Mustard is cultivated mostly in the districts of Salem, Visakhapatnam, Coimbatore and Nilgiris. Linseed is mostly confined to Visakhapatnam, Bellary, Cuddapah, Salem and Anantapur districts, safflower to the Ceded districts and Niger to the Central and northern districts. Research work on these crops has not yet been taken up in Madras, but an attempt has, however, been made to collect some varieties from the important districts and study their relative performance at Coimbatore.

Safflower (Carthamus tinctorius).—Safflower is grown extensively in Bellary district and to a lesser extent in Anantapur and Kurnool districts. It is little known outside the Ceded districts and is chiefly grown on the black soils in the late season in October and November. It is grown as a mixture with coriander, sorghum or wheat. As a pure crop it is sown only on the borders of fields where its spiny bracts serve as a protection against trespass. The seeds yield a straw coloured sweet oil, used for culinary purposes.

Work done on the crop—Isolation of improved strains.—At the Agricultural Research Station, Hagari in Bellary district, five high yielding cultures have been isolated. The seeds of these are being multiplied on a small scale for distribution in the Bellary district. Of these, culture CT 11, is a non-spiny type.

Genetical studies.—There are two distinct types of plants, the spiny and the spineless. The density of bloom also varies on the bracts. The florets show a diversity of colours as white, yellow, red and orange. Inheritance of some of these important characters was also studied. It was found that "Spiny" nature of the involucal bracts was a simple dominant over "non-spiny". "Heavy bloom" on the bracts differed from its allelomorph, "the sparse bloom" by a single factor.

There was linkage between the two sets of allelomorphs—spiny, spineless and heavy bloom and sparse bloom.

The four colours of the florets, viz., white, yellow, red and orange were controlled by three factors, highly complementary to each other. It has been established by a study of natural crosses and artificial crosses that a basic factor "Y" produces the yellow colour and that a supplementary factor "R" produces red colour in the presence of "Y". A third factor "O" in conjunction with "R" produces the orange colour which in turn depends on the presence of factor "Y" the basic colour factor, for its manifestation. The inheritance of these flower colours was found to be independent of the characters like the nature of bracts, etc. The chromosome number in safflower was determined to be $2n=24$

OIL BEARING TREES.

Oil Palm (Elæis guineensis).

To study the possibility of introducing the West African Oil Palm in South India, seeds of the palm were obtained 18 years ago and planted in three different soil types, viz., coastal sand, deep laterite and sandy loam on the coconut Research Station on the West Coast. The palms were studied for growth, yield and other characters.

Though the palms commenced to flower in about three years after planting, the yield has not been satisfactory, especially, in the case of trees growing in coastal sand. The maximum yield recorded for a tree in any one year has been 4,000 nuts weighing about 60 lb., the average being about 1,250 nuts weighing about 20 lb. A preliminary study of the palm fruits gave the following data :—

	PER CENT.		PER CENT.
Kernel to whole nut ..	14	Oil in kernel ..	45
Husk	32	Oil in husk	73

Tung oil tree (Aleurites spp).—The tung oil tree, the fruits of which yield the tung oil, the well-known drying oil of commerce, is being experimentally raised at a few places in South India. Twenty fruits were obtained from such centres and were analysed for physical characters and the percentage of oil. Both from the percentage of oil in the kernels and general development, the fruits from Tirunelveli district appeared better than the others, as can be seen from the following data :—

	Travancore sample.	Darjeeling sample.	Tirunelveli sample.
Average weight of fruit (grammes) ..	11·8	22·8	29·6
Percentage (by weight of nuts to the fruit)	41·8	40·0	44·0
Percentage of kernel in the nut ..	59·0	52·0	62·0
Percentage of oil in the kernel (on moisture-free basis)	61·9	65·0	64·0

The Government Lecturing and Systematic Botanist is conducting trials in introducing the tung oil trees in Kallar, Burliar and Coonoor in Nilgiris, in Wynaad and at Araku Valley. A few plants of *A. fordii* grown in the Sim's Park, Coonoor, have begun fruiting and seem to fare well at an elevation of about 6,000 feet.

Oils for burning in lamps.—At the instance of the Government, an extensive enquiry was made into the scope and availability of the different vegetable seeds for extracting oil for burning in lamps. Samples of seeds of the more important ones, viz., Pungam (*Pongamia glabra*), Pinnai (*Calophyllum inophyllum*) tobacco seeds, neem (*Azadirachta indica*) Illupai (*Bassia* spp) and Marotti (*Hydrocarpus wightiana*) were collected from the different parts of the State and their oil contents determined. The oils were also tested for their suitability for burning in lamps like Magan deepa, Rama deepa, etc., designed to use vegetable oils from the point of smokiness, smell, light intensity, burning time, etc. Some of the less viscous oils were found quite suitable for the purpose. The survey showed that Madras State possesses a potential supply of 15,200 tons of vegetable oils from thiis source alone, if only the seeds could be gathered and crushed regularly.

STATEMENT A.

(1)	TMV. 1 (AH 25) (2)	TMV. 2 (AH 32) (3)	TMV. 3 (AH 698) (4)	TMV. 4 AH 334) (5)	AH 4111) (6)	(AH 4205) (7)
1 Average acre yield of pods in pounds.	1,550	1,640	1,640	3,500	1,580	1,590
2 Shelling percentage ..	73·5	77·0	77·6	75·6	78·2	78·6
3 Weight of one Madras Measure of pods in pounds and ounces.	1–4½	1–5½	1–6¾	1–4¾	1–7¾	1–8
4 Weight of one Madras Measure of kernels in pound and ounces.	2–11½	2–13¼	2–12	2–11½	2–14½	2–14½
5 Number of kernels per pound.	940	1,425	1,130	890	1,164	1,172
6 Oil content of kernels (on moisture free basis in percentage.)	49·1	47·6	49·6	50·2	49·5	50·0
7 Duration in days ..	135	105	135	135	100	105
8 Remarks—Selection, hybridization, habit, etc.	Selection from Saloum, West Africa variety. Spreading.	Selection from Spanish short type in duration. Bunch.	Selection from Bassi West African variety. Spreading.	Selection from American variety Carolina. Spreading.	Selection from local Gudiyattam. Bunch.	Selection from local Gudiyattam. Bunch.
9 Special attributes, if any.	Somewhat drought resistant, possesses smooth pods and harvest is comparatively easy.	High shelling percentage and natural test weight of pods.	High shelling percentage and natural test weight of pods. Pod formation in the soil is shallow.	Has large number of three-seeded pods.	..	....

STATEMENT A—*cont.*

	(AH 4218)	(AH 4515)	(AH 2105)	(AH 3741)	(AH 4354)	(AH 6481)
	(8)	(9)	(10)	(11)	(12)	(13)
1 Average acre yield of pods in pounds.	1,620	1,596	1,523	1,580	1,650	1,250
2 Shelling percentage ..	77·9	78·1	76·3	77·1	76·5	76·0
3 Weight of one Madras Measure of pods in pounds and ounces.	1–8½	1–8	1–4	1–8¼	1–7	1–4½
4 Weight of one Madras Measure of kernels in pounds and ounces.	2–15	2–14	2–10	2–11	2–11¼	2–13
5 Number of kernels per pound.	1,159	1,201	809	1,064	1,082	1,058
6 Oil content of kernels (on moisture free basis) in percentage.	50·6	49·9	50·1	51·5	50·7	49·0
7 Duration in days ..	100	100	125	120	130	110
8 Remarks—Selection, hybridization, habit, etc.	Selection from local Gudiyattam. Bunch.	Selection from the South American variety Casilda 5. Bunch.	Selection from African Native Tanganika. Semi-spreading.	Selection from local Salem. Semi-spreading.	Selection from Spanish Bombay. Semi-spreading.	Selection from cross between local and Tanganika. Bunch.
9 Special attributes, if any.	..	....	....	....	....	.... Dormant seeds.

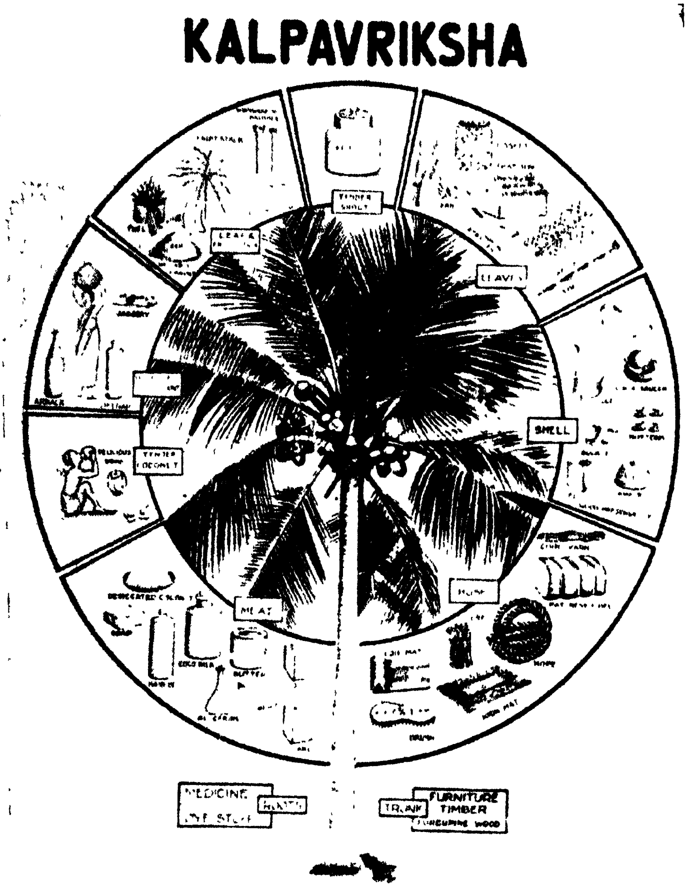

Plate 36.—The Coconut Tree.

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CHAPTER 7.

THE COCONUT (*COCOS NUCIFERA*, LINN).

Area, production and utilization—varieties—Seed selection—General cultivation practices—Coconut Research—Morphology and anatomy, cytological and genetic studies—Factors affecting yield—Agronomic and manuring experiments—Crop improvement—Nurseries—Introduction of varieties—Hybridization—Studies on Coconut products, copra, oil cake, coir—Tapping and jaggery making—Research Stations for Coconut.

(Local names: Tamil—*Thengai*; Telugu—*Kobbari*, *Tenkaya*; Kannada—*Tengu*; Malayalam—*Nalikeram*; Hindi—*Narial*).

Introduction.—The coconut is one of the most important oilseed crops of the tropics. Every part of the tree is utilized in one way or other in our national and domestic economy. The raw nut and edible copra are important articles of food and indispensable items of divine oblation and religious functions. Oil obtained from the copra is utilized in cooking, and industrially for the manufacture of vegetable ghee, soaps and toilet articles. The cake is extensively used as a cattle food on the west coast. The water or milk of the tender nut is a refreshing drink during the hot days. The husk gives coir fibre out of which a variety of products such as yarn, mats, brushes, etc., are manufactured. The shell is burnt and often converted into charcoal, which is in demand for the manufacture of gas masks. Spoons and ladles are made out of the shell and also decorative articles by skilful craftsmanship. The trunk of the palm is useful as timber and the leaves are used in thatching roofs, making baskets, mats, brooms, etc. The sweet juice obtained by tapping the unopened spathe (flower bunch) is an invigorating drink when fresh or may be converted into jaggery (palm gur). The apple inside the germinating nut, and the tender crown are delicacies. Some of the parts of the palm are recognized to have exceptional nutritive and medicinal properties. The juice from the kernel is a substitute for milk and contains vitamins A and B. The kernel of the tender nut is a diuretic and the tender nut water is useful in bilious fever and urinary disorders. There are innumerable other uses to which the various parts of the tree are put. It is no wonder that the tree is called "*Kalpavriksha*" or "*The Paradise Tree.*" (Plate 36).

Area, production and utilization.—The area under the coconut in the Indian Union is about 1·5 million acres with an annual estimated production of 3,300 million nuts. The Madras State with 6·2 lakhs of acres and 1,500 million nuts accounts for 41 per cent of the acreage and 46 per cent of the total production in India. Travancore comes next with 38·4 per cent of the acreage and 37·2 per cent of the production. In Madras more than 85 per cent of

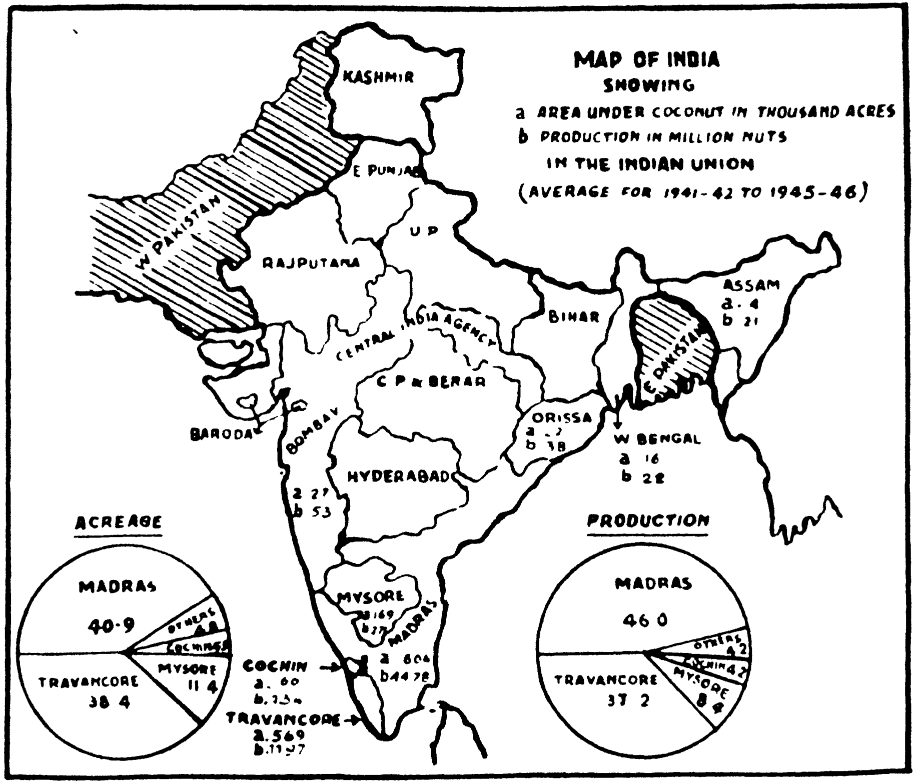
the area is concentrated in the West Coast districts of Malabar and South Kanara. The other two important districts for coconut cultivation are East Godavari (56,000 acres) and Tanjore (36,000 acres). A review of the acreage for the past 15 years shows a definite, though small, increase. Due to the prevalence of attractive prices for the coconut and its products in recent years there has been a great fillip among the cultivators to plant fresh areas and also underplant old gardens. This is a healthy sign, and if these favourable conditions continue the area under the coconut is certain to increase. (Plate 37).

Prior to World War I, when the Indian oil crushing and soap industries had not developed, India had a net exportable surplus of copra and coconut oil, but since 1920 the position has reversed. India's present production falls short of her requirements by about 50 per cent. Out of the estimated annual production of 3,300 million nuts, 1,500 million nuts are converted into copra and the rest used for edible and ceremonial purposes. Eighty per cent of the 220,000 tons of copra produced is used for crushing, yielding 108,000 tons of oil. The present demand is estimated to be 150,000 tons of oil. The panel on oils and soaps has estimated the requirements of oil in the next five years at 210,000 tons on the following basis :—

	Present demand.	Demand expected in the next five years.
	TONS.	TONS.
Soap Industry	35,000	60,000
Toilet and domestic use	45,000	60,000
Edible purposes	66,000	80,000
Other cases	6,000	10,000
Total ..	152,000	210,000

The present deficit is being met by imports from other countries at a cost of roughly ten crores of rupees per year. In the next five years this deficit will be 102,000 tons, i.e., of the same order as the present production. The question of imports of copra and coconut oil from foreign countries is likely to meet with difficulties. The only solution appears, therefore, to step up the production if the industries based on coconut oil are not to be starved and the internal prices are to be kept at reasonable level.

The scope for the development of the coconut industry has to be viewed both in its long, and short term aspects. Unlike in annual crops, the production cannot be stepped up immediately by increasing the acreage. A recent survey has shown that in Madras an overall increase in the acreage of about 50 per cent is possible and as a long term policy this has to be encouraged. Large areas fit for raising the coconut are available in the interior of South Kanara and Malabar districts especially in the lower slopes and at the foot of the hills. Marked expansion is also possible in Tanjore and East Godavari and to a small extent in



MAP OF INDIA
SHOWING
a AREA UNDER COCONUT IN THOUSAND ACRES
b PRODUCTION IN MILLION NUTS
IN THE INDIAN UNION
(AVERAGE FOR 1941-42 TO 1945-46)
KASHMIR
E PUNJAB
W PAKISTAN
RAJPUTANA
U P
CENTRAL INDIA AGENCY
C P & BERAR
BIHAR
ASSAM
a. 4
b 21
E PAKISTAN
ORISSA
b 38
W BENGAL
a 16
b 28
BARODA
BOMBAY
a 27
b 53
HYDERABAD
MYSORE
MADRAS
a 604
b 4478
COCHIN
a. 60
TRAVANCORE
a. 569
ACREAGE
MADRAS
40·9
OTHERS
COCHIN
MYSORE
11 4
TRAVANCORE
38 4
PRODUCTION
MADRAS
46 0
OTHERS
4 2
COCHIN 4 2
MYSORE
TRAVANCORE
37 2

Plate 37.

the other districts without encroaching on the area sown to food crops. The immediate problem of stepping up production has to be tackled in the existing areas. Evidence in foreign countries and experiments conducted over a quarter of a century at the Coconut Research Station in Madras have demonstrated beyond doubt that proper cultivation and manuring increase the yields considerably. Timely action to combat pests and diseases which do damage to the coconut is also necessary to ensure high yields. What is required is an appreciation of the situation and a planned exploitation of the internal resources to free the country's dependence on foreign imports.

Coconut cultivation.—A brief account of the cultural practices adopted by the ryots and the improvements advocated are given so that the value of the research work detailed in the later paragraphs can be appreciated.

(*a*) *Climate.*—The coconut is successfully cultivated within 23 degrees on either side of the equator. The limit of altitude depends on the latitude and on the temperature, generally 2,000 feet above sea level is the limit. Plantations at higher latitude and altitude are reported to be unproductive. The palm tolerates a wide range of humidity and temperature in India while elsewhere it is said to thrive well only in places having a fairly constant temperature. On the west coast where the main coconut area is located, the monthly mean of minimum temperature does not fall below 70° F and that of the maximum rise above 92° F, while the relative humidity is also high ranging between 72 to 92 per cent. The annual rainfall in the important coconut growing regions ranges from 60″ to 150″. Excellent coconut gardens are found in Phillippines (rainfall 40″) and in Mysore (rainfall 25″) but this is because there is a plentiful supply of subsoil water. In the point of distribution of rainfall coconut areas in India suffer because there are at least three months during the year when practically no rain is received. In Ceylon and Malaya rainfall is received during all the months of the year. Therefore the average yield of nuts in India is much below that obtained in Ceylon and Malaya.

(*b*) *Soil.*—The best soil for the coconut is rich alluvium with a fair proportion of sand or coarser particles to ensure proper drainage. The largest area under the coconut on the west coast is located in the red laterite soils but these are deficient in phosphate, potash and lime. The coconut also thrives and yields well in black clayey soils. It is also successfully grown in pure sandy soils provided there is an assured under-ground supply of water and the trees are adequately manured. Soils lacking in water holding capacity and suffering from excessive dryness or improper drainage are unsuitable for coconut cultivation. The stem bleeding disease is common in tracts where the drainage is poor. Palms standing on bunds of rice fields yield very well, because under these conditions sufficient aeration of the roots, adequate supply of water to the plants and good amount of light to the leaves are assured.

(c) *Varieties.*—The planter recognizes several varieties of the coconut based on the variations in the colour, shape and size of the nut, fullness of the crown, etc. The variety largely cultivated in India and the other coconut growing countries is the tall variety as distinct from the dwarf. The tall variety palms are long lived (80 years and more), hardy, and yield copra, oil and fibre of good quality. They commence to bear in eight to ten years after planting when grown under unirrigated conditions. The dwarf variety palms are delicate and short lived (30 years) and are more easily susceptible to the attacks of pests and diseases than the tall variety. They begin to yield in about four years after planting but the nuts are small and the copra is of inferior quality. This variety is grown mainly for earliness and attractive colour of the nut (deep green, yellow or orange) in favoured localities. (Plate 38.)

(d) *Seed selection.*—The selection of seed material is of the greatest importance in the coconut, which lives for 80 years or more. Any neglect in this respect will adversely affect the planter for a considerable number of years and the situation cannot be easily remedied as in annual crops. The usual practice with the coconut cultivators is to obtain seednuts from reputed seed centres and raise the nursery or to purchase the seedlings from such centres. The professional nursery man who is more concerned with his immediate profits, is naturally averse to adhere to the rigid standards of selection. The ryot will discover the poor quality of the seedlings only when they come to bearing in eight or ten years by which time large amount of money and energy would have been spent. To prevent such wastage and ensure the planting of guaranteed seedlings the State Government has opened nine coconut nurseries under a comprehensive coconut nursery scheme with the assistance of the Indian Central Coconut Committee. These nurseries are located at Anakapalle (South Visakhapatnam), Maruteru (West Godavari), Samalkot (East Godavari), Tindivanam (South Arcot), Pattukkottai (Tanjore), Marudur (Tiruchirappalli), Coimbatore, Pattambi (South Malabar) and Nileshwar (South Kanara). At these nurseries a total of 166,000 selected seedlings are produced every year for distribution.

The process involved in the production of selected seedlings is a prolonged one. At first, parent trees which are healthy, middle aged, high yielding, with thickest crowns, producing medium sized, nearly round shaped nuts are selected and marked after extensive survey of the gardens in the tract. Fully mature nuts from such trees are carefully harvested during the months of February to May. Generally the top and bottom nuts in a bunch are undersized and are rejected. Care must be taken to see that the nuts are not immature and there is sufficient water inside the nuts. Seed nuts are not taken from alternate and irregular bearers and also from trees producing barren nuts. These nuts are brought to the nursery site and preserved in sand till they are required for planting. On an average not more than ten per cent of the trees in a plantation come up to the required standard of a good parent

Plate 38 (*a*).—*High yielding coconut trees.*
A. Suitable for propagation.

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Plate 38 (b).—High yielding coconut trees. P. 264

B. Unsuitable—Note the weak drooping leaf stalks and buckling bunches.

Plate 39.—Coconut Nursery (Pattambi) with 3 months old seedlings. P. 266

tree and from each such tree about 20 to 25 ideal seed nuts can be expected in a season. The nursery area is located in a sandy plot or if this is not possible it is made up of sand to a depth of a foot. The seed nuts are planted in the seed bed in a vertical position to a spacing of one foot either way, at the commencement of the south-west monsoon. This saves the expenses on heavy watering required in the initial stages. The nursery is not manured as this will mask the quality of inherently poor seedlings. Germination commences in the third month and continues till the eighth month. Usually 90 to 95 per cent of the nuts germinate. The nursery is mulched, shaded and watered on alternate days during the summer months. The final selection of the seedlings is done when the seedlings are about a year old. Only seedlings which are healthy, vigorous, possessing large number of leaves, and good girth at the base, and show signs of splitting of leaves into leaflets are selected. In such a rigid selection only about 60 seedlings can be obtained for 100 seed nuts planted in the nursery. The rejected seedlings are destroyed. (Plate 39.)

(e) *Plantings.*—The land selected for planting should be cleared of all jungle growth, levelled and contour bunds laid out. If the land is slopy terracing is necessary to prevent soil erosion. The ryots plant seedlings rather close and indiscriminately. When trees are overcrowded they grow lean and lanky and considerable energy is wasted at the expense of yield. A spacing of 25 feet between the trees either way giving 80 trees per acre is suitable for most places of average fertility. The triangular method of planting trees has been found to economize space and some 15 per cent of trees more could be put in by this method than by the square method adopting the same spacing. Planting should be done at regular intervals to facilitate cultural operations with labour saving implements. Planting of seedlings at the surface of the soil or in shallow pits about a foot deep just sufficient to cover the nut is inadvisable, especially under the dry system of cultivation and in places where the water table is low in the summer months. The base of trunk to a height of two to three feet is the root bearing region and therefore it should be well within the soil, otherwise root production is limited and the palms suffer much in dry weather. The depth of planting depends upon the nature of the soil and the height of the water table. Generally with three feet deep planting will suffice, but in hard gravelly soils with low water table planting may be done at a depth of four feet. Along river banks planting can be done at one or two feet depth. On rice field bunds and back water areas seedlings are best planted in mounds two or three feet high. Pits of the size of three feet by three feet and the required depth are dug a couple of months before planting and the sides charred by burning rubbish to prevent white ant attack. Younger seedlings establish more quickly when transplanted than older ones but are subject to damage in transit, attack by white ants and may not withstand water logging in rainy months. So the best time at which seedlings can be removed from

the nursery for transplanting is when they are about a year old. Planting is done just after the heavy rains. The seedling is kept in position and the nut is covered with the soil and pressed down. While planting a foot of loose soil made up of earth, sand and ash (10 lb.) is provided at the bottom of the pit.

(*f*) *Care of young plantation.*—The seedlings should be properly fenced to prevent cattle trespass. They should be watered regularly in the absence of rains till they establish themselves. Watering and shading the seedlings are also necessary in the dry summer months. The usual practice is to water every alternate day in the first summer and twice a week in subsequent years till the plants are five or six years old. The seedling pits should be kept free of weeds and the seedlings examined regularly for pests and diseases. In the early years, manuring at 10 lb. of ash and ¼ lb. of ammonium sulphate per seedling will be sufficient. This dose may be increased as the seedlings grow.

Under favourable conditions the young palms commence flowering in about five years after planting. In loamy soils the flowering may commence in seven to ten years while in barren sand or hard gravelly soils it may be delayed till 15 or 20 years. The first few bunches produced are usually barren and in the early period the bunches may be produced irregularly. The trees begin to yield normally in about five years after the first flowering. Thereafter an inflorescence is produced roughly at monthly intervals and a bunch comes for harvest every month. The tree continues to give economic yields till it is sixty years old or more, when the plantation may be under-planted.

(*g*) *Manuring and cultivation.*—Systematic and judicious manuring is necessary to obtain economic returns from coconut gardens. The ryots commonly apply ash at 15 to 20 lb. per tree. Artificials are very rarely applied but fresh fish, green leaves, are applied when available. Cattle or sheep penning or application of cattle manure is done in the Godavari delta and also green manuring with sunnhemp. Manures are generally applied in circular basins round the trees or rarely broadcast either in May–June or September–October. Excepting by a few well-to-do ryots manuring is not done systematically. The best manure for the coconut is 4½ lb. of ammonium sulphate or 15 lb. of groundnut cake and 20 to 30 lb. of ash per tree per year in addition to the raising and ploughing in of a green manure crop every year. For green manuring *Crotalaria striata*, a local leguminous weed, has been found to be the best for coconut gardens. The best time for the application of manures is September–October when there is sufficient moisture in the soil. Ammonium sulphate is applied in linear trenches along with the green manure, while ash is best applied broadcast over the entire area and ploughed in.

Inter-cultivation of a coconut garden is of the greatest importance especially in gardens raised under unirrigated conditions. The ryots generally dig up the gardens once or rarely twice in a year while some of them are content to dig only to a radius of four feet round

Plate 40 (a).—Systematic inter-cultivation and manuring to improve the yield of the coconut. A well-cultivated and manured garden.

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Plate 40 (b).—Systematic inter-cultivation and manuring to improve the yield of the coconut. A neglected garden. P. 270

the trees. Cultivation with labour saving implements is not generally possible due to indiscriminate planting. In Mysore and Godavari the area is ploughed a number of times in a year while in Tanjore only digging is possible on account of close planting. The proper cultivation for a coconut garden is to plough it once in May–June and a second time in October–November and work a cultivator twice or thrice during the summer months. It has been established that mere cultivation without manuring is better than mere manuring without cultivation. To ensure proper yields regular and adequate manuring and cultivation are necessary, and by adopting the above recommendations the yields at the Coconut Research Stations have been increased and maintained at a high level. (Plate 40.)

(h) *Catch crops and subsidiary crops.*—The coconut cultivator does not get any income from the garden for the first few years. To make up for this, catch crops are usually grown for about five years after planting. The crops commonly cultivated are tapioca, sweet potato, pulses, millets, yams, etc. Subsidiary crops are also grown in bearing coconut gardens with a view to supplementing the income from the coconut crop. Tapioca, pine apple, dry rice, etc., can be grown successfully if manured adequately without any harmful effects on the coconut.

Coconut research.—Research work on the coconut commenced with the opening of four research stations in the Kasaragod taluk of the South Kanara district in 1916, as a result of the decision of the Government of Madras that a detailed study of the coconut in all its aspects should be undertaken on the west coast where the crop is cultivated extensively and where the income derived from the trade in its products and bye-products is considerable. In order to obtain representative soils on which coconuts are generally cultivated three blocks of vacant land were selected and acquired near Nileshwar, viz., Pilicode (Nileshwar I) representing laterite gravelly soil, Nileshwar II—red sandy loam and Nileshwar III—coarse barren sand. Work at these stations in the earlier years consisted of laying out the area, procuring seed nuts from reputed seed centres, raising nursery and planting up, and regular experimental work could be started only after 1930. A block of existing plantation was also acquired in 1916 at Kasaragod (red loamy soil) and cultural and manurial experiments, morphological studies, etc., were started soon after. This station was sold to the Indian Central Coconut Committee in 1947. A wealth of data has been collected at these four Coconut Research stations and the more important items are detailed in the following sections:—

I. *Morphological and anatomical studies—The root system.*—The coconut belongs to the class of monocotyledons and the roots are adventitious without the tap root. The main roots are about 0·4 inches in diameter and may bear branches which in turn have numerous branchlets one to two mm. in thickness. These small rootlets are short lived and are replaced frequently. There are no root hairs in the coconut. The old roots are very rigid, strong and

woody and therefore the tree is able to withstand strong wind. The roots which go vertically down to a depth of 20 or 30 feet are termed as "water roots" and are supposed to be mainly utilised for supplying water, while the "feeding roots" found spreading horizontally to a depth of about three feet supply mineral nutrients and the "*breathing roots*" supply air to the internal tissues. All the roots emanate from the bole, i.e., the enlarged portion of the base of the trunk. As normally no functional roots are found on the stem above ground and as the thickness of the roots is very uniform, the maximum number of roots which can be produced depends on the surface area of the bole. In a deep planted tree there is scope for production of a large number of roots than in a surface planted one.

The number, length and spread of roots is largely controlled by the nature of the tree and conditions of soil-moisture and cultivation. The total number of roots varies from 1,500 to 2,500 in a poor grown-up tree, to even 7,000 in a vigorous, healthy tree. The horizontal roots may be 15 to 30 feet in length while the water roots almost reach the permanent water level.

Root studies.—(*a*) A seedling just germinated has only three roots, and a one year old seedling has nine roots with a total length of about 17 feet. Early germinated seedlings have better root development than late germinated ones.

(*b*) In a seedling about 18 months old the mean number of roots is 12, with a mean length of 32 feet, the lateral spread is up to five to six feet and the penetration is ten feet.

(*c*) In a six year old seedling the total number of roots is 596 with a maximum spread of 18 feet. The largest number of roots is found within a distance of one foot from the stem and three-fourths the total number of roots lie within a depth of four feet from the ground level.

(*d*) Comparative study of the root system of the seedlings of the Dwarf and the Ordinary west coast variety showed that though there is not much difference between the number of roots in the two varieties, the ordinary variety had definitely larger spread and deeper penetration of the roots.

(*e*) It was found that pruning of the roots before transplanting of one year old seedling was not harmful provided it is properly manured and watered after planting. Roots not pruned were found dead and all the functioning roots were produced subsequently.

The stem.—The stem of the coconut is an erect, unbranched stout cylinder. It is derived from one terminal growing point, which is located at the very tip of the trunk, and it is minute, nearly ½ mm. square and found enveloped by leaf after leaf in varying stages of development. The stem is first formed when the seedling has produced 12 to 18 leaves, i.e., two to three years old. In the first few years of growth the stem gradually increases in thickness and uniform girth is maintained thereafter throughout its life, excepting in very old stages when it tapers off. Slight,

though recognizable, variations are caused in the thickness of the stem due to soil, rainfall, manuring and cultivation, diseases, etc., and are records of the vicissitudes through which the palm has passed.

Length of stem.—(*a*) The length of the stem increases with age; the growth is rapid in the early years (two feet per year) and slows down later (less than six inches a year in a 40-year old tree). The greatest length of stem recorded is 117 feet in Ceylon, but the average in the west coast is 50 to 60 feet.

(*b*) The length and girth of the stem are influenced by the system of planting. When planted close, the trees tend to grow tall, provided the soil is fertile; the girth is the largest for the most widely spaced trees.

(*c*) The elongation of the stem is very rapid in the red loamy soils but in barren sandy soils, it is slow and poor.

(*d*) The growth of the stem is also markedly influenced by manuring and cultivation. Application of ammonium sulphate and ash increased the girth of stem by 42 per cent; of ash alone, by 27 per cent; while the other manures tried reduced it to less than 19 per cent. In a period of 15 years the percentage increase in height in manured and cultivated plots was 96 while in unmanured and uncultivated plots it was only 68.

(*e*) Correlations worked indicate that length of the stem is highly related to yield and the age at first flowering. This would mean that a tree having long stem not only yields well but also commences to flower early.

The leaf.—The coconut leaf consists of many leaflets arranged obliquely on the midrib. The young leaf first appears in the centre of the crown as a pointed arrow and at this stage all the leaflets are held together. The top leaflets open out as the leaf grows and four months elapse from the appearance of the leaf tip to the emergence of the lowermost leaflet. As the leaf gets older it is gradually pushed aside to provide space for the younger leaves. By the time it dries up and is about to shed, which may be from $2\frac{1}{2}$ years to $3\frac{1}{2}$ years, it would have covered an angle of 120° to 170°. The leaves of the heavy bearers turn through a wider angle than those of the poor bearers or young trees.

(*a*) *Leaf development.*—From the dissection of the crowns of 183 fourteen-year old underplanted trees the development of the leaf was studied. The number of leaves inside the bud was either equal to or one and a half times the number of leaves opened. The average number of opened leaves per tree was 11·39 and the average number in the cabbage was 14·92. The maximum length of the opened leaf was over 17 feet including the five feet long petiole. The study revealed that most of the development of the leaf takes place four to five months prior to the complete emergence of the leaf.

In a mature, bearing tree there are thirty to forty leaves at various stages of growth in the cabbage. The leaves which are

to open for the coming two years are found formed with distinct petiole, rachis and developing leaflets. On good trees there are four sets of leaves. Counting from the oldest leaf they are—

(i) 10 to 12 leaves from the axils of which the bunches are already harvested; (ii) 10 to 14 leaves with bunches in various stages of maturity; (iii) 10 to 12 leaves in the axils of which the spadices have not yet opened; and (iv) 30 to 40 leaves in the cabbage.

(b) *Leaf arrangement.*—The leaves are arranged on the top of the trunk in five spirals which may run to the left or to the right and the angle of deflection between successive leaves in the spiral is nearly 144°. This angle of deflection varies from tree to tree and also in different rounds of the same spiral. This arrangement ensures the supply of maximum amount of light to the leaves. The bunches are thrown on the right if the spiral is to the left and vice-versa. The spiral is to the left in most of the trees. The number of leaflets to the right side of the leaf is slightly larger. Even though the direction of the spiral varies from tree to tree it remains the same throughout the life of any particular tree. A recent study on the inheritance of the spiral nature did not reveal any relationship between the parents and their progeny, which leads to the conclusion that the nature of the spiral is not an inherited character.

(c) *Rate of leaf production.*—The rate of production of leaves measured in terms of days taken for the opening of two successive leaves, is influenced by the age and vigour of the palm, fertility of the soil, cultural practices and seasonal conditions. On an average, 12-13 leaves are formed in grown-up trees in a year and the number may be nine or less in younger trees and trees growing in unfavourable localities.

(i) Late germinated seedlings, which are poor in vigour have a slower rate of leaf production than early germinated seedlings.

(ii) The average number of leaves produced and the average interval of the production of successive leaves are in favour of cultivated plots (14·9 and 24·25 days respectively) while in an uncultivated plot they are 12·6 and 27·2 respectively.

(iii) Leaf production is slower for surface-planted trees (11·6) leaves than for deep-planted palms (12·0 leaves).

(iv) Rate of leaf production was more rapid at Kasaragod (loamy soils) than at Nileshwar III (barren sandy soil) and at Pilicode (gravelly laterite soil).

(v) Rate of leaf production is generally low in April, May and June and rapid in September, October and November.

(d) *Shedding of leaves.*—The rate of shedding of leaves depends upon the age and nature of the palm, season, soil and cultural treatments. Under favourable conditions, the leaves of a vigorous palm remain for three to three and a half years; while

in poor trees leaf shedding is early, and in some trees the shedding may take place even before the bunch in its axil matures. Leaf shedding is high during the hot weather ranging from 40 per cent in loamy soils to nearly 60 per cent in barren sandy soils and low during the south-west and north-east monsoon periods.

(e) *Variation in leaf length.*—The length of leaf increases rapidly from 2½ feet in one-year old seedlings to 13½ feet in palms seven years old. Thereafter the increase is slow till about the 25th year after which the leaf length gradually decreases. The longest leaf is found in 15–16 years old palms. High yielders have comparatively longer leaves than low yielding trees. Cultivation and manuring also result in the increase of leaf length. Variations in length between the different leaves of a tree may be as high as 2½ feet. Leaves produced in the cold season are shorter than those produced during the rainy season. Though the heavy yielding palms generally have longer leaves, a few palms with short leaves also are found, in which case the number of leaves is more.

Floral Biology.—The commencement of flowering is an important event since it is then that the planter is very near the reward for his patient care and labour. The age at which the tree first flowers depends upon a number of factors such as vigour of the palm, soil and climatic conditions.

The inflorescence of the coconut is a spadix, about four feet long, stout in the middle and tapering above, at first erect and finally drooping. The spadix is enclosed in a long boat-shaped spathe. The main rachis of the spadix has a number of branches called spikes with numerous male flowers and a few female flowers at the base. The development of the inflorescence starts about 15 months before its opening. The development of the female flowers commences about 12 months before the opening of the inflorescence and that of the male flowers a month later. The inflorescence develops rapidly only about six months before its opening.

In the earlier stages of flowering, production of spadices is irregular, the production being confined mostly to the summer months. In about three to five years the production of spadices becomes regular, i.e., a spadix is produced in the axil of every leaf. In a regular bearer the number of leaves and spadices produced are almost the same, i.e., 12 per annum for most palms. It takes about three to four months for the opening of the spadix from the time it first appears in the leaf axil. The bursting open of the spathe takes a day or two in the summer months, and in heavy bearers the spathe may open in a day. The blooming of the male flowers commences from the apex of the spikes and continues downwards. It is a gradual and continuous process lasting on an average for about 18 to 21 days. The number of male flowers in an inflorescence may vary from 150 to 5,000. But the average is generally 3,000. The female flowers are much bigger than the male flowers and their number per spathe may vary from 25 to 60, but the average is about 25. The tendency to produce only male

flowers in an inflorescence is common in the early period of flowering. The female flowers open one to three days after the end of male phase and remain receptive for about three days. Wind and insects are the pollinating agents. Cross-pollination is the general rule but there are fair chances for self-pollination also during summer.

(a) *First flowering.*—(i) The first flowering was noted in the fifth year at Kasaragod (red loamy soil), in the seventh year at Pilicode (gravelly laterite soil) and in the eighth year at Nileshwar III (barren sand) in the case of surface planted trees. In the tenth year the percentage of palms flowered was 90, 54 and 80 respectively in the above three soil types.

(ii) No difference in the mean age at first flowering was noted for surface planted and one foot deep planted trees.

(iii) Number of leaves and the length of the stem are significantly correlated to age at first flowering. Large number of leaves and a tall stem indicate the vigour of the palm and may be taken as characters of early flowering eco-types.

(iv) Manuring and cultivation do not appear to influence the age of first flowering.

(b) *Production of spadices.*—(i) Production of spadices is influenced by the age of the palms, nature of planting, soil, cultivation, etc. At Kasaragod (red loamy soil) there are no trees with less than ten open spadices, and 50 per cent of the trees produced 12 or more spadices in a year. On the other hand at Pilicode only seven per cent of the trees produced 12 spadices and about 40 per cent of the trees less than ten spadices per year. Leaf production at these two stations corresponds to the production of spadices.

(ii) Consequent on cultivation and manuring the production of spadices increased by 11·8 per cent in the case of poor bearers and 5·8 per cent for medium bearers while the heavy yielding trees did not respond to the treatment.

(iii) Seasonal variations in the production of spadices were noted. Larger number of spadices are produced during the summer months February to May than during the cold months.

(c) *Abortion of spadices.*—(i) Abortion of the spadices occurs at a very early stage in its development. This is more frequent in the young trees; only about 34 per cent of the trees from among the 18 years old palms at Pilicode had spadices in every leaf axil, and the majority of trees produced less than seven spadices per year. In 40-year old palms at Kasaragod only six per cent of the trees had one or more barren axils.

(ii) About 75 per cent of the spadices which abort are those which are due to open in the months of July to October. The only important factor which might obviously affect the development of the spadix is the drought about 15 months prior to its opening.

(d) *Production of female flowers.*—(i) The production of female flowers shows remarkable increase due to cultivation and

manuring in the poor bearers only (33·3 per cent) and to a less extent in the medium bearers (19·9 per cent). But in heavy yielding palms the response is little.

(ii) Production of female flowers is highest during the summer months February–May and lowest from September–January.

(e) *Button shedding.*—Even though an inflorescence may produce large number of female flowers or buttons on an average about 80 per cent of them are shed and only about 20 per cent develop into nuts. The causes for the shedding of buttons may be many, such as effect of seasonal and cultural conditions, lack of pollination or fertilization, attack of pests and diseases, etc. Some of the buttons shed show fungus attack but it is not known whether this is the primary cause or whether the fungus appears only when the button is about to shed. Spraying with one per cent Bordeaux mixture and artificial pollination did not reduce button shedding. In a recent trial conducted with Planofix, a fruit drop inhibiting hormone, the inflorescence was sprayed at fortnightly intervals from the commencement of the female phase. The results did not show any improvement in setting due to sprayings.

Under the Scheme of Research on Coconut in Madras, a detailed study of the button shedding was undertaken on two palms in each of seven world varieties and 25 ordinary tall palms of five different yield groups for a period of three years.

There is very little shedding before the opening of the female flowers, the mean number of female flowers shed being only 4·87 per cent of the total production. Most of the shedding takes place within six weeks after stigmatic receptivity and it is maximum from the second to the fourth week after stigmatic receptivity. During the first fortnight about 38 per cent and during the second about 32 per cent of the total female flowers are shed. It is very much reduced during the third fortnight. The shedding percentage also varies from tree to tree. In 4·6 per cent of the trees the shedding percentage was 50, while in 18·4 per cent of the trees 89 per cent of the female flowers were shed. On an average 80 per cent of the total female flowers was shed. The percentage of shedding due to insect attack and disease was negligible. Shedding was maximum during the rainy season and minimum during the cold season. It was rapid during the hot months and the period of shedding was more spread out during the cold season.

Appreciable differences were observed in the total production and shedding of buttons, the difference being more pronounced in the world varieties than in the ordinary variety. In the low yielding trees shedding was very rapid during the first fortnight of stigmatic receptivity unlike in the high yielders where it was more spread out. About a third of the buttons shed in the ordinary tall variety of West Coast had all the three or two cells developed (presumably unfertilised) while the remaining two-thirds

had only one cell developed. It was just the reverse in the case of the world variety trees. Among the world varieties the percentages of shedding ranged from 77 to 98. Maximum shedding occurs in Fiji, New Guinea and Cochin China varieties and minimum in Ceylon, Philippines and Laccadive small. The annual variation in the percentage of female flowers shed was not much; in 1944 about 74 per cent and in 1946 about 79 per cent of the total female flowers produced were shed.

(*f*) *Setting.*—From the view point of the planter the number of nuts harvested to the number of female flowers produced is the most important consideration. This setting percentage varies from 14 to 30 and is much higher in heavy and medium bearers than in poor trees. The high yield of heavy bearers is due to the high production of female flowers as well as to high setting. This does not necessarily mean that all trees producing a large number of female flowers are good yielders. In fact, the percentage of setting in such trees may be as low as seven, and in trees producing low number of female flowers the setting is high. Setting is also affected by seasonal conditions. It is high during the months of September-January and low in summer months, when the production of female flowers is the highest.

Anatomical and cytological studies.—The structural and developmental anatomy of the root, stem, leaf and inflorescences of the coconut were studied. The important findings are summarised in the following :—

(*a*) The structure of the root, stem and leaf conforms to that of the monocotyledonous type. There are no root hairs in the coconut. The impervious nature of the root is due to the thick exodermis (hypoderm). There is extensive aerenchyma in the old roots. The so-called " breathing roots " are thicker than the normal, more spongy with the conducing tissues poorly developed. Adventitious roots arise from the ground tissue of the stem. The epidermal cells of the young root are multinucleate. The nucleii in the various tissues are characterised by multinucleolate condition.

(*b*) The meristematic nature of the ground tissue persists for a considerable length of time in the life of the stem. The vascular bundles are " closed " collateral ones each with a " heavy cap " of fibres and are produced in two stages. The early ones have more than one vessel and the late ones have usually only one xylem element. The weakness of the stem is due to the persistence of the thin walled conjunctive tissue even in the old stems. The normal cork tissue is wanting; but a special type of periderm called the " storied " type-rhytidome is present in the periphery.

The girth of the old stem is much greater than that of the seedlings. This is due to the increased activity of the growing point and the consequent increased production of vascular bundles in the trees, and not due to secondary thickening.

(*c*) The leaf (petiole portion) is first differentiated from the growing point of the stem about thirty months prior to its

emergence from the leaf sheath. The blade portion begins to form about eight months later, from tip of the young petiole. The basal leaflets are the oldest. The formation of the blade is completed about six months, and the stomata about three months prior to the emergence of the leaf. The epidermis of the leaflets originates from the periblem and not from the dermatogen. There are four motor tissues in the leaflet which help in the unfoldment of the leaflet.

Due to the thick cuticle, the extensive palisade tissue and the hypoderm of the leaflets and the highly thickened peripheral cells of the stem, the coconut is essentially adapted to withstand xerophytic conditions. But as in hydrophytes, there is aerenchyma in the roots which helps in withstanding waterlogging and epithem (hydatode) at the margin of the leaflet to remove super-abundant water. Thus the coconut is adapted to withstand extremes of weather conditions.

(*d*) The development of the inflorescence is a slow process taking about thirty-four months from the time of the differentiation of the flower primordium to the opening of the spathe. The maximum elongation occurs during the period of six months prior to the opening of the spathe. The branches of the inflorescence begin to form about sixteen months prior to the opening of the spathe. Severe drought occurring at this period kills the primordia of the spadix and it aborts. The primordium of the female flower is first differentiated about twelve months before the opening of the spathe or about two years before the harvest of the nuts. The male flowers begin to form a month later than the female and mature a month before the stigma is receptive. The ovary is first differentiated about six to seven months and the ovule about two months prior to the opening of the spathe. From the formation of the archesporium to the complete development of the embryo sac it takes about two months. The time of tapping toddy corresponds to the period when the tetrad (microspore) is being formed and when the anthers are full of sugars and nourishing fluid. On the inner side of the stigmatic nectaries, a small cambium and a few cork cells are found. The splitting of the spathe is effected by interval pull set up by the decreased turgescence in the tangentially elongated cells, as also by the pressure exerted by the rapidly developing spadix within the spathe. The function of tannin cells and raphides characteristic of almost all tissues is protective.

(*e*) *Nectar secretion in the coconut.*—A detailed anatomical study of the coconut flowers with special reference to nectar secretion revealed certain new features which have not been reported upon previously. The salient points are the following:—

(i) Septal nectaries and hydathodes are for the first time reported upon the coconut.

(ii) Nectar is secreted by the stigmatic surface and by three septal nectaries which are provided with outlets below the stigma. There are no secreting glands at the base of the ovary.

(iii) The epidermal hydathodes exude a liquid in the region below the stigma. Under South Indian conditions in the tall type of palm, the exudation occurs before stigmatic receptivity and does not exclude ants from reaching the stigma.

(iv) In the male flowers also the secretion of nectar is effected by septal nectaries situated in the pistillode.

(*f*) *The chromosome numbers in the coconut.*—The chromosome numbers in the tall and the dwarf varieties of the coconut were determined. Both had the same chromosome number, viz., $n=16$ and $2n=32$.

The yield.—Ordinarily it takes a year after the opening of the female flowers for the nuts to mature and become fit for harvest. The development of the fertilized female flower is rapid in the early stages, and the maximum weight (6 lb.) and volume (3,000 c.c.) of the nut is attained in the sixth month. At this stage the fibre in the husk is not well formed, the shell is thin and soft and the beginnings of the kernel are seen. The water or milk inside cover the entire space and this is the correct stage for the harvest of tender nuts. Subsequently the growth consists entirely in the development of the kernel, shell and the husk, and when the nut is mature there is some shrinkage in volume and considerable fall in weight of the nut (3 lb.). The development of the copra and oil content is rapid from the eighth to the eleventh month.

The factors which determine the yields in the coconut are the number of spadices opened, the number of female flowers produced and set. These are affected by various causes such as inherent character of the trees, age of the palm, season and rainfall and the manuring and cultivation given.

(*a*) *Inherent variations in yield.*—The population of trees in a garden consists of (1) alternate bearers which give heavy yields in alternate years, (2) irregular bearers, whose yields vary from year to year and do not conform to any system and (3) regular bearers. Among the regular bearers that yield uniformly over a number of years, three types, viz., heavy, medium and poor bearers are found. The medium and poor trees respond to cultural and manurial treatments, while the heavy yielders do not. At the Kasaragod station out of 134 trees under detailed observation for 12 years, 8 are alternate bearers, 31 irregular bearers and 95 yield regularly. Of the regular bearers 23 per cent are heavy bearers yielding about 100 nuts per tree per year; 70 per cent are medium bearers with an average yield of about 59 nuts; and 7 per cent poor bearers with an average yield of 25 nuts. The annual variations in yield are very high for the poor bearers and low for the heavy bearers. The heavy yielders are, therefore, the best eco-types for cultivation and if a plantation were to consist of only this type of trees the yield would be heavy.

The characteristics of the eco-types are—

Per tree, per year (average of 12 years.)	Heavy bearers.	Medium bearers.	Poor bearers.
1 Annual yield of nuts	99·8	58·8	25·0
2 Number of spadices produced ..	13·4	12·8	11·4
3 Number of female flowers produced	370	263	135
4 Percentage of setting	26·9	22·3	18·5
5 Total number of functioning leaves	33·8	29·5	28·0
6 Height in 1931 in feet	28·4	25·6	22·3
7 Number of female flowers per bunch	27·6	20·5	11·8
8 Number of nuts per bunch ..	7·4	4·6	2·2

It is clear from the above figures that heavy bearers are superior to the other groups in every respect. Heavy bearers possess, besides factors which contribute to yield, significantly more number of leaves and greater length of stem. Correlations worked have established that the number of leaves is found related to the yield over a longer period and that a mature tree with a large number of leaves would have yielded well in the past and is likely to yield well in the future. Long stem is associated with heavy yields. These two characters, viz., number of leaves and length of stem appear to be independently related to yield and are the most important characters in locating the eco-types.

(b) *Other factors that effect yield.*—(i) The age of the palm affects the yield particularly in the early period and also in the last stages of the life of the palm. During the first few years of bearing, generally five, one or more spadices are barren and spadices may not be produced in the axils of all leaves. The number of fertile spadices per tree and the number of female flowers per spadix gradually increases up to the tenth year of bearing. Variations in setting percentage appear to be independent of the age of the tree. The yield of the tree increases up to a certain extent as the age increases and full yields in early good bearers are obtained five years after the commencement of bearing.

(ii) Monthly and annual variations in yield have been noted. Between 50 and 60 per cent of the nuts mature during the months of March to June due to high production of bunches and female flowers, and the yield obtained from September to January is very low. Yearly variation in yield is about 12 per cent and is probably due to seasonal conditions, as no periodicity is noted.

(iii) Rainfall has a profound effect on yield. Rains received during the south-west monsoon and early part of the north-east monsoon bear no relation to yield under West Coast conditions. A detailed investigation revealed that yield in any particular year is influenced by January to April rains of the two years previous to harvest together with the rains in January to April of the year of harvest.

(iv) A study of the relationship between the yield of trees and the ground area occupied showed that spacing influenced the yields to a considerable extent. Under the dry system of cultivation on the West Coast a spacing of 25 feet between trees is necessary.

(v) As already stated the number of leaves is related to the yield. The rate of leaf production also appears to be related to the yield. The interval between the opening of successive leaves is shorter in high yielders than in poor yielders. The yield being an expression of the physiological activity, the catalise activity of the leaf is correlated to the yield.

(vi) Cultivation and manuring show considerable effect on the yield, more particularly the former.

(vii) Tapping of coconut spathes increases the yield in the post-tapping period in the case of poor bearers only, and the effect lasts for about four years. Continuous tapping of a tree for more than a season or at the most two is harmful.

(c) *Production of barren nuts.*—Production of barren nuts, i.e., nuts without kernel or with kernel partially developed or decaying is a phenomenon usually met with in gardens all over the coconut tracts. It is reported that production of barren nuts in Pattukottai (Tanjore district) has increased considerably of late. At the Kasaragod Station the average percentage was 2·55 in 1939–40. Some particular trees produced as high as 42·2 per cent of barren nuts. The monthly variation of barren nuts ranged from 1·28 to 5·04 per cent, it being high in May-June and low in September to December. Artificial pollination of 15 trees producing barren nuts did not show any beneficial effect. Tapping the trees, however, showed a definite reduction in the production of barren nuts in the post-tapping period in the case of 2 out of the 5 trees under trial (reduction from 18·3 and 16·5 per cent to 5 to 0 per cent respectively). Since trees producing barren nuts yielded as much toddy as healthy ones it appears profitable to tap barren trees.

II. *Agronomic experiments.*—There are two limiting factors in the layout of agronomic experiments on the coconut. They are—

Certain practical difficulties are encountered in the layout and interpretation of agronomic experiments on the coconut. Since the spacing of about 25 feet given for the trees is large there is difficulty in allotting sufficient number of trees per plot. Taking only two trees per net plot and ten trees for gross plot an area of five to six acres is required for an experiment with four treatments and six replications. In such a layout 80 per cent of the trees are non-experimental, border rows, and considerable variation due to soil fertility will be introduced. The absence of uniformity in the bearing capacity of the trees and varying response by the different eco-types (i.e., heavy, medium and poor yielding trees) also introduces variation. In the earlier experiments evaluating the effects of treatments with pre-treatment period as basis was

found more efficient than comparison with control. In the present set of experiments this difficulty is got over by selecting plots, whose yields in the pre-treatment period are not significantly different from one another.

Another handicap is that the effect of the treatments on the yield of nuts is seen only two or three years after the commencement of the experiment, and the experiment has to be continued for a period of six to eight years to obtain conclusive results. The reason for this delay in the manifestation of the effect of the treatment is evident from the following facts :—

(i) That the abortion of the spadices is affected by the conditions existing about 16 months prior to the opening of the spathe or 28 months prior to harvest, and (ii) that the primordia of the flowers are formed about two years before the harvest and the differentiation of the female flower about 18 months prior to the harvest. The treatment affects the formation of the primordia of the spadix and the flowers.

(1) *Cultural experiments.*—(*a*) Cultural experiments were started in 1918 and the observations made for over quarter of a century have given results of first rate importance. The effects of the treatments are brought out clearly in the following table :—

Treatments.	Mean annual yield of nuts, 1920–39.	Coefficient of variation per cent.
No manure and no cultivation	10·3	72·81
Cultivation alone without manure ..	47·6	17·25
Cultivated and manured	64·3	14·62

The importance of regular cultivation is clear from these figures. Variations in the annual yield are considerable in the neglected plot, while regular cultivation ensures a steady yield.

A plot which was regularly cultivated and manured was left untreated for a period of five years (1932–39) to study the deterioration of the garden. The data obtained are—

	Mean yield of nut per tree, per year.
Preceding neglect (1928–31)	66·1
During neglect (1933–35) first three years.	61·8
During last year and the year succeeding neglect (1936–39).	42·2
Succeeding years (1940–48)	59·0

The trees were giving good yields preceding neglect and also during the first three years of neglect. The deterioration manifested thereafter and continued for a period of three years after cultivation and manuring were restored. The trees showed recovery three years after manuring and cultivation was started again.

Regular cultivation is of the utmost importance in the successful raising of the coconut grown under rainfed conditions. The cultivation of the garden even without manuring is better than applying manures in basin trenches and leaving the

rest of the area uncultivated. Cultivation considerably improved the production of female flowers and yield of nuts. Soil moisture determinations showed greater moisture retention in the cultivated plot than in the uncultivated, particularly in the deeper layers and during the summer months.

(b) *Trenching experiments.*—The local method of applying manures to the coconut is to open shallow basin trenches round the trees at the beginning of south-west monsoon and to cover them up after manuring at the end of north-east monsoon. The root pruning resulting from this type of trenching is believed to benefit the trees. To test this belief, circular basin trenches (six feet radius and one foot depth) and linear trenches (two feet wide and two feet deep) in between rows of trees were opened at the beginning of the south-west monsoon, filled up with green leaf or compost and covered in November. Leaf production and shedding was not much affected but the production of flower bunches and female flowers and consequently the yield showed increase in linear trenched plots, while in circular trenches the yield was reduced on account of lower production of female flowers and setting. Linear trenches are, therefore, to be preferred to circular basin trenches in the case of surface planted trees.

(c) *Ploughing versus digging.*—An experiment was started in 1942 to find out the effect of ploughing with " Monsoon plough " and digging with Mamaty on the yield of nuts, and the minimum number of ploughings required to get the best yields. Ploughing thrice a year gave the highest net profit per acre, but the gross return was slightly higher in the case of digging nine inches deep.

(d) *Earthing up experiments.*—To find out whether earthing up the base of surface planted trees in summer months would improve the trees which suffer from excessive drought, an experiment was started in 1942. Mounds of earth two and half feet high were made at the base of the trees in January and removed in May-June when rains set in. No significant differences in respect of leaf and female flower production and yield were observed.

(2) *Manurial experiments.*—(a) The first set of manurial trials was started in 1922–23 and continued till 1931–32. Ammonium sulphate, pottassium sulphate, super phosphate, ash, cattle manure, fish guano, salt and lime were tried singly and in certain combinations. The yield figures under this experiment were not strictly comparable as the number of trees under each treatment was small and the pre-treatment differences in yields were rather considerable. Nevertheless the results indicated that response to manuring was more pronounced in the low yielding trees than in the high yielding ones. Application of ammonium sulphate and pottassium sulphate with or without super appeared to be slightly beneficial. Addition of lime had a depressing effect on yield. Ammonium sulphate alone (three lb.) did not benefit

the trees, but with an additional dose of ash (20 lb.) gave substantial increased yield. Cattle manure was the next best, but it benefitted only poor yielding trees. Coconut cake, fish guano and salt gave poor response.

Based upon these indications a second experiment was laid out in 1932 and continued up to 1937. The results obtained are—

Treatment (per tree, per year.)	Yield of nuts per tree, per year.		Differences.
	Pre-treatment (1919–22).	Due to treatment (1934–37).	
Three lb. of ammonium sulphate and 20 lb. of ash applied broadcast.	25·5	52·0	26·5
Three lb. of ammonium sulphate and 20 lb. of ash applied in trenches.	22·0	46·0	24·0
Cattle manure 100 lb. applied broadcast.	28·0	45·0	17·0
Cattle manure 100 lb. applied in trenches.	34·5	46·0	11·5
Ash 20 lb. applied broadcast	33·0	41·0	8·0
Ash 20 lb. applied in trenches ..	28·0	42·0	14·0
Fish in trenches	35·5	49·0	13·5

The results conclusively proved that three lb. of Ammonium sulphate and 20 lb. of ash was the best manure for the coconut. As for the method of application the differences are not high and broadcasting is to be preferred as it is cheaper.

A third set of experiments was started in 1938 and continued up to 1946 to find out the most economic dose of ammonium sulphate, and also the possibility of substituting ash with pottassium sulphate as ash is not available locally in sufficiently large quantities. The manures were applied broadcast and a green manure crop was raised and ploughed in every year. The plots also received the usual cultural treatments, viz., two ploughings and two or three hoeings every year. The yield data are—

Treatment (per tree,) per year.	Mean yield of nuts per tree per year.	Cost of treatment per tree.	Increase in yield over T1.	Difference in cost of treatment over T1.	Value of the increased yield over T1 (at Re. 0-2-3 per nut).
(1)	(2)	(3)	(4)	(5)	(6)
		RS. A. P.		RS. A. P.	RS. A. P.
T_1 20 lb. of ash	58·7	0 4 0	—	..	..
T_2 20 lb. plus 1½ lb. of ammonium sulphate.	62·4	0 7 0	3·7	0 3 0	0 9 2
T_3 20 lb. plus 3 lb. of ammonium sulphate.	59·2	0 10 0	0·5	0 6 0	0 1 2
T_4 20 lb. plus 4½ lb. of ammonium sulphate.	68·0	0 13 0	9·3	0 9 0	1 4 11
T_5 3 lb. of ammonium sulphate and 1½ lb. of pottassium sulphate.	61·0	0 11 3	2·3	0 7 3	0 5 2

Z test significant. Critical difference four nuts.

Conclusion $\underline{T_4, T_2, T_5, T_3,} T_1$

The results show that the application of 20 lb. of ash and four and half lb. of ammonium sulphate has recorded a significant increase in yield and that this dose is the most economic one. Since there is no significant difference between T_4 and T_5 one and half lb. of pottassium sulphate can be substituted for 20 lb. of ash without affecting yields.

(*b*) *Groundnut cake-manuring experiment.*—During the war, ammonium sulphate was in short supply, and an experiment was designed to find out whether groundnut cake could be used instead. Application of three lb. of ammonium sulphate was compared with nine lb. of groundnut cake, and since no significant differences in yields were noted for a period of four years, it was concluded that groundnut cake could be substituted for ammonium sulphate.

(*c*) *Husk burial experiments.*—The soils on the West Coast, in general, are poor in organic matter and coconut trees grown under rainfed condition suffer from severe drought in summer. An experiment was started in 1937 to find out whether burying husks (dry husks, not fit for coir making) and dry coconut leaves would benefit the trees. The treatment consisted of burying about 1,000 husks and 300 leaves per tree, in linear trenches six feet wide and 12 inches—15 inches deep. A green manure crop was raised and incorporated every year and no other manure was applied till 1947, but the plots received the usual cultural practices. A significant increase in yield was noted from the third year onwards and the effect lasted for a period of five years. The burial of coconut husks and leaves is, therefore, a useful method of improving the coconut garden under rainfed conditions.

(*d*) *Green manure trials.*—Green manuring is another method of improving the soils by the addition of large quantities of organic matter. The best course is to raise a green manure crop in a coconut plantation and plough it in. A green manure crop for the coconut should satisfy certain special conditions as it has to be raised under the shade of the trees. It has to be raised with the help of the summer showers and south-west monsoon rains so that it is ready for ploughing in September-October. A number of crops such as groundnut, wild indigo, sunhemp, etc., were tried with a view to fixing up the best green manure for the tract. Each crop had some defect or other that made it unsuitable. In the case of groundnut it was difficult to obtain sufficient seed for sowing the next crop. Yield of green stuff was poor in wild indigo. Cowgram gave fairly good results when cattle manure was applied but in certain years it was badly attacked by insects. It could not tolerate water logging in the soil even for a few days. Sunhemp was too delicate a plant and it required a basal dressing of ash. Therefore the search for a suitable crop was continued among the local leguminous weeds. *Crotalaria striata*, *Cassia tora* and *Cassia occidentalis* were selected from among the weeds which grow abundantly during the rainy

Plate 41.—A good crop of Crotalaria Striata-green manure crop in a coconut garden

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season in the tract and tried. The latter two did not tolerate cultivated conditions but *Crotalaria striata* was found to come up very well in the shade of the coconut trees. This new green manure crop was successfully tried at all the coconut Research Stations and yields of up to 20,000 lb. of green stuff per acre were obtained. If sown in April-May the crop would be ready for cutting in September-October. It is able to withstand the heavy rains and has the following additional advantages:—

(i) Seed production is plentiful and the seeds being small, the seed rate is low.

(ii) The seed keeps viable for long periods even in humid weather.

(iii) After two or three years of continuous sowing a self-sown crop can be expected.

(iv) The crop is not relished by either cattle or goats and can, therefore, be cultivated in coconut gardens, which are not properly protected by a fence.

(v) The plant has very few pests except caterpillars attacking the pods.

Crotalaria striata is, therefore, the best suited green manure crop for the coconut plantations particularly in the west coast. (Plate 41.)

A scheme for the multiplication and distribution of *Crotalaria striata* is being worked from 1948 onwards in eight taluks of Malabar and South Kanara districts with the assistance of the Indian Central Coconut Committee. Every year 125 lb. of seeds are distributed in each taluk to raise the crop in five acres of primary seed farms and the seeds obtained from this area are purchased at a premium for distribution at a subsidized rate for further multiplication in that taluk.

Miscellaneous agronomic experiments—(*a*) *Surface planting.*—Among the surface planted trees at Nileshwar II heavy casualties were observed in the early stages. Therefore for comparison 44 seedlings were planted in one foot deep pits in 1922. In 1929–30 it was observed that larger number of surface planted trees had flowered than the deep planted ones; but the growth in general was better in the deep planted trees.

From a root study of the surface and the deep planted seedlings it was observed that the surface planted seedlings had more number of roots and leaves in the first two years only than the deep planted ones. The concentration of roots was according to the depth of planting. As the seedlings grew older the surface planted ones suffered more due to the drought in the summer than the deep planted ones. Surface planting was therefore found not desirable under rainfed conditions and in places where the water table is low in summer.

(*b*) *Cultivation of the coconut in barren sandy soils.*—At the Agricultural Research Station, Nileshwar III where the soil is barren sand to a depth of 20 feet and the water table is low during

the summer months, trees planted on the surface have not fared well. The time of first flowering, which is an index of vigour, was delayed considerably and at the end of ten years only 20 per cent of the trees had flowered whereas 90 per cent had flowered at Pilicode (gravelly laterite) and Nileshwar II (red sandy soil). The yield, when the palms were 22 years old, was as low as ten nuts per tree per year. Of the various treatments tried to improve these trees, lowering three to six years old trees by one foot was harmful as leaf production and flowering were retarded for about fifteen years after the treatment. Application of clay at 7,000 cubic feet per acre (to a thickness of two inch) was also not successful as the yields were depressed. Burial of husks and leaves showed the best improvement in vegetative activity and yield. Seedlings planted at the Station in one foot deep pits in 1927–28 have come up much better and 60 per cent flowered at the age of ten years. Surface planting has not been successful in poor sandy soils where the water table is very low in the summer months.

(c) *Depth of planting experiment.*—Surface planting in the poor sandy soils being unsuccessful, an experiment was started at Nileshwar III in 1939, to find the proper depth of planting. Seedlings were planted in pits three feet and six feet deep pits in 1939. The palms have not yet flowered but from the data of 1947 it is observed that leaf production and number of functioning leaves are in favour of the three feet planting.

(d) *Replanting adult coconut trees.*—In 1933 twenty selected surface planted 14-year-old trees were bodily removed and replanted in three feet deep pits. After a set back for a period of five years they have begun to yield normally. A deep constriction on the stem marks the period of the set back.

(e) *Watering experiment.*—To find out the increase in yield of nuts due to watering of the trees in the summer months an experiment was started in 1945 on one-foot deep planted trees at Nileshwar III. In 1948 significant differences in favour of watering were noted in the number of functioning leaves, and in the next year, differences in the number of female flowers produced and the yield of nuts were also significant. The experiment is being continued and a similar experiment was started at Nileshwar II (red loamy soil) in 1949.

(f) *Cultivation of subsidiary crops.*—With a view to supplementing the income of a coconut grower, trials were made with a number of subsidiary crops raised under rainfed conditions in the interspaces among coconut trees. Dry rice, Varagu, Tapioca and Pine-apple were found to come up well and give economic returns if the crops are adequately manured. The raising of subsidiary crops had no adverse effects on the yield of coconut trees.

Crop improvement.—The coconut commences to bear in about ten years after planting and gives economic yields for 60 years or more. An eminent plant breeder remarked that the life of the

coconut covers three human generations. The problem of crop improvement, therefore, becomes a very difficult and a prolonged one probably one of the most difficult of all the cultivated crops. Another difficulty encountered is that because of extensive cross pollination there is wide variation in all palm characters and there is strictly no pure variety in the coconut. Evolution of pure lines is an impossible task taking the time factor into consideration and also the area required to plant and study the progenies. Further selfing has been found to reduce the vigour in the progeny and therefore continued selfing instead of purifying the type may cause down-right deterioration by the large accumulation of undesirable genes. The method of crop improvement in the coconut has, therefore, to be tackled in other ways.

Selection.—A survey of ordinary coconut gardens has shown that only 10 to 15 per cent of trees are heavy yielders, 50 to 60 per cent are medium bearers and the rest are poor yielding eco-types. A proportionately small fraction of the population in a plantation is responsible for a large portion of about 25 per cent of the yield. This, therefore, indicates a fruitful line of improvement, namely, inclusion of more number of high yielding eco types in a garden. It has been stated earlier that from the point of view of yield, the length of the stem and the number of functioning leaves are the most important characters in locating high yielding eco-types in a garden where all the palms are of the same age and have received identical cultural and manurial treatments. Since cross pollination is the rule in the coconut the task of the breeder is to find out the characters by means of which the high yielding eco-types could be identified in the nursery. The number of leaves, the height and the girth, besides the time taken for germination, are the only available characters to judge the vigour of the seedlings. In most crops vigour in the early stages is judged by the development of the shoot. Further, based on the study of palm characters, it is reasonable to expect that a seedling having a large number of leaves and a greater height will continue to have a large number of leaves and a long stem, when it grows into a tree and, therefore, prove to be a good yielder. The performance of trees raised from selected seedlings supplied in the earlier years and also planted at the Coconut Stations confirms this view. These characters are, therefore, utilized in selecting good seedlings and rejecting poor ones.

(a) *Nursery experiment.*—For the purpose of raising coconut seedlings, selected seed nuts are obtained from selected, high yielding parent trees. It is necessary to make a selection in the nursery also to spot out vigorous seedlings which alone should be utilized for planting. The vigour of the seedlings is judged from various characters such as height, girth, number of leaves and roots. Detailed study of the characters of the seedlings was undertaken at Nileshwar III Station in 1932 and continued in

subsequent years. Some of the important observations made and recorded are the following :—

(i) Seednuts began to germinate in 12 weeks after planting; the germination was maximum during the 17–18th week after which there was a gradual fall and it stopped in the 32nd week.

(ii) The earlier germinated seedling had more number of leaves and was, therefore, more vigorous than the late germinated ones.

(iii) Early germinated seedlings were significantly better than those germinating late in respect of girth and height also. Death rate was greatest among the late germinated seedlings.

(iv) A seedling with good height and girth had a well developed root system.

(v) Seednuts from high setting palms gave very high percentage of early germination. This character is associated with high yield.

(vi) Artificially cross pollinated seednuts gave high percentage of early and total germination as compared with selfed and naturally pollinated seednuts. Nuts obtained by crossing the tall (mother) and dwarf (father) varieties of the coconut were outstanding in early and total germination.

(vii) Seednuts harvested in the summer months of February to May were superior to those of rainy or cold months in respect of (*a*) early germination, (*b*) total germination and (*c*) characters like girth and number of leaves and therefore vigour.

(viii) Over-dry seednuts of about 13 months and undermature nuts of 11 months are inferior to fully mature 12 months-old seed nuts. The age of the nut relates to the period from the time of opening of the female flower to the time of harvest of the nut.

(ix) In a bunch, nuts which were either too small or too large germinated late, if at all.

(x) Nuts from heavy bunches, i.e., bunches with more than 12 nuts gave better early germination than nuts from lighter bunches.

(xi) Heavy nuts gave 97 per cent while the light ones gave only 59 per cent germination.

(xii) Nuts with very thick or very thin husk gave lower percentage of germination, then nuts with husk of medium thickness, i.e., 0·55 to 0·84 inch.

(xiii) Spheroid nuts gave higher percentage of early germination than oblong or linear nuts.

(xiv) Nuts at the top and the bottom of the bunch gave less percentage of germination than those from the middle of the bunch. The top and bottom nuts in a bunch are usually small and deformed.

(xv) Seednuts with sufficient water in them gave higher percentage of germination than those with little or no water.

Plate 42.—Coconut seedlings (one year old). P. 294

1. *Poor (rejected).* 2. *Good (selected).*

Note the vigour of the selected seedling as compared with the rejected.

(xvi) Two positions of planting, viz., vertical and horizontal were tried. There was no significant difference between the two in respect of early or total germination. The vertical position usually adopted by the ryots is to be preferred, because it is more convenient and economical for planting in the nursery, and for packing and transport of seedlings.

(xvii) There is no significant difference in the total germination of seednuts from young, middle-aged and old trees. The usual practice in the tract is to select nuts from middle-aged trees as these are in the prime of their life and give high yields. The inherent characters are not fully manifested in either very young or old palms and it is more difficult to make a proper selection of such trees.

(*b*) *Preservation of seed coconuts in sand.*—The seed coconuts are usually harvested in the summer months, but planting in the nursery can be done only in June-July. It is, therefore, necessary to preserve the seednuts carefully from February to May so as to avoid the drying of the water inside the nuts. Preservation of the seednuts in sand was tried with success. The seednuts were placed vertically on a one-inch layer of sand and completely covered over with sand to a depth of an inch above the nuts. It was found that nuts could thus be preserved for a period of nine months without deterioration. Nuts stored loose for the same period were found dry and unfit for seed purposes.

(*c*) *Selection of seedlings.*—A good seedling should be healthy and well grown with about eight to ten leaves at the age of one year. The base of the collar should be thick, about five inches in circumference. Such a seedling has good root development and is heavy. It should be tall about four feet high and show early signs of splitting of leaves into leaflets. Only seedlings satisfying these criteria are selected for distribution. (Plate 42.)

(*d*) *Study of the germinating nut and seedling.*—With the object of finding out the changes taking place as the nut germinates and grows into a seedling, germinating seednuts were removed from the nursery at monthly intervals and studied. Root production commences in the second month after planting the seednut in the nursery and the number of roots increases with the age of the seedling. The apple begins to grow even at the end of the first month and fills the cavity in five months when the water disappears completely, and thereafter, it loses its sweetness and becomes papery as the seedling grows. The first normal leaf appears in the fifth month (the first one or two scale leaves produced immediately after germination are rudimentary) and the number of leaves gradually increases to six or eight by the end of a year. Splitting of leaves was noticed for the first time in about a year after germination. A gradual increase in the girth at collar and height of the seedlings and the number of roots is maintained. There is a gradual fall in the weight and thickness of the kernel of the nut and it disappears altogether in the 22nd month. The

copra made from the kernel at intervals showed a steady rise in the percentage of oil.

Introduction of varieties.—Coconut varieties and forms from the important coconut growing countries were obtained and planted at the Coconut Research Station, Pilicode in 1921 and 1924. The palms have been studied in detail for the different vegetative and economic characters.

From the study it is seen that all the varieties and forms can be broadly divided into two main groups, viz., the tall and the dwarf varieties. In each group there are a number of forms or agricultural varieties, and in each there may be a number of eco-types. The existing collection, which is by no means complete, has been classified into five varieties and nine forms and a key for their identification prepared. Due to extensive cross pollination occurring in nature it is difficult to maintain the purity of the type in the coconut. In the dwarf variety self-pollination is common and progenies often breed true to the parent. It is possible to distinguish even in the seedling stage the tall and the dwarf types by means of their characters. Laccadive ordinary, Laccadive small, Andaman ordinary and Cochin China were found to be some of the promising forms. But these have not been tried on any large scale as planting material available is limited. Laccadive ordinary is a high yielder and appears to be even better than the local tall variety. Laccadive small is best suited for making ball-copra, and Cochin-China gives tender nuts with a plentiful supply of sweet milk. Laccadive ordinary and Andaman ordinary yield nearly double as much sweet toddy as the local tall type. For ornamental purposes the dwarf variety is the best. The famous San Ramon of Philippines which is a very high yielder of copra per nut, and Nyiur Gading of Malay States which is an early and heavy bearer are not available in the Pilicode collection.

The introduction of varieties requires considerable caution, because all varieties are not cosmopolitan and may not do well in this country as soil and climatic conditions are different. Most of the imported varieties did not come up to expectation at Pilicode. The size of the nut went down and the quality of copra was inferior in many cases. Also while introducing new varieties the risk of introducing new diseases into the healthy tract should be seriously considered and guarded against.

An experiment to spot out the varieties and types suitable to low-lying areas has just been started at the Pilicode station.

Hybridization.—As the possibility of improving the coconut by selection and introduction of varieties from other countries was limited, hybridization work was taken up in 1932 even though it is a tedious and long process. The main object of the work was to spot out parental combinations that would give vigorous seedlings but not as in annual crops, to evolve better types for further multiplication and distribution. Crossing was attempted first between high yielding eco-types possessing desirable economic

Plate 43.—Progeny of Tall (female) × Dwarf cross (Nileshwar). P. 298
Note the vigour and high yielding nature of the young palm which is only 4 years old.

characters which contribute to increased yield. Later the work was extended to eco-types with different yielding capacities to study the behaviour of their progenies. Also hybridization between different varieties was attempted. The progenies, over 2,000, were planted at Nileshwar II, and are under study. These are young and have not yet come to the normal bearing stage; but the study of vegetative characters has given encouraging results and indicated the future lines of work.

(a) The following four schemes of hybridization were taken up in the year 1932–33 :—

Scheme I.—Cyclic crosses between parents with five economic characters, viz., (a) High yield, (b) High female flower production, (c) High setting percentage, (d) Thick meat and (e) Big size of nut.

Scheme II.—Reciprocal crosses between parents with high female flower production and high setting (in Scheme I all the parents selected were high yielders, while in this scheme, the yields alone were not taken into consideration).

Scheme III.—Crosses between regularly bearing and irregularly bearing parents. The object was to find out whether the high yielding nature of irregular bearers could be combined with the regular bearers. Only the ordinary West Coast tall type of trees were used for these three schemes.

Scheme IV.—Inter-varietal crosses between the ordinary tall as the mother and the dwarf as the father were attempted. The object was to find out whether the early bearing nature of the dwarf and good nut characters of the tall could be combined in the progeny. Earliness of bearing will reduce the cost of cultivation.

The hybrid nuts were planted in the nursery and were studied in detail. In Scheme I a few naturally pollinated and selfed nuts were also planted for comparison. Progenies of high setting mother were distinctly superior in respect of early germination. Progenies of Tall × Dwarf crosses gave very high percentage of early germination and the total germination was cent per cent. The progenies were planted at Nileshwar II in 1934 to 1936. (Plate 43.)

A detailed study based on the vegetative characters of the seedlings under Scheme I was made. The conclusions were that self fertilization was not likely to be of benefit in coconut breeding, as in no instance did the selfed seedlings prove superior to the crosses, and that hybrid vigour could be induced in the coconut, this finding opened a new path in coconut improvement. The presence of distinct hybrid vigour in Tall × Dwarf progenies possibly resulting from the combination of the characters of two distinct varieties was noticed.

The Tall × Dwarf progenies were the earliest to flower, i.e., in four years after planting. The yield performance of these trees

has been recorded. Most of them are in the initial stage of bearing. Details of flowering and yield are given in the following :—

Scheme.	Parent flowered till the end of 1943.	Average per tree in 1946. Nuts.	Average per tree in 1946. Female flowers.
I	33·2	6	35
II	31·4	4	46
III	..	..	..
IV (Tall × Dwarf) ..	88·3	37	245

The following yield data of the self and naturally pollinated progenies in Scheme I show that the crosses are the best and the selfed progenies the poorest :—

	Average per tree in 1946. Nuts.	Average per tree in 1946. Female flowers.
Cross	6	35
Natural	3	24
Self	2	17

The performance of the progenies in 1949 is as follows :—

Progenies of Scheme I are fairly good. Crosses involving thick meat and high female production are more vigorous than the rest. Seedlings under Scheme II are poor and those under Scheme III are disappointing as only four out of 40 have flowered. The Tall × Dwarf hybrids continue to be outstanding. These are early bearers with high yield and good quality of copra and are therefore in great demand by the public.

(*b*) Under the Scheme of Research on Coconuts in Madras, financed jointly by the State Government and the Indian Council of Agricultural Research first and later by the Indian Central Coconut Committee, a detailed study of progenies obtained by self, natural and controlled cross-pollination of trees belonging to six yield groups was made. A total of 108 parent trees were selected and the nuts obtained by the three methods of pollination were planted in the nursery in 1940. A study of over 2,500 one-year old seedlings indicated that in respect of number of leaves, height and girth at collar crosses and naturally pollinated seedlings were superior to those obtained by self-pollination. There was also a general indication that seedlings obtained from higher yield groups were more vigorous than those from lower yield groups.

As per the recommendations of the Advisory Board of the Indian Council of Agricultural Research an area of about 12·5 acres was specially acquired and 750 of the progenies were planted at Nileshwar II in 1942. These are being observed for the various characters relating to growth. The progenies are young and only

a few of them commenced flowering in 1947. The performance of the seedlings in 1949 is given in the following table :—

Particulars.	Mean number of days for emergence of successive leaves.	Mean number of leaves on the crown.	Mean length of leaf in cms.	Mean number of leaflets.	Mean number of leaves produced since planting.	Total number of palms flowered since planting.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(i) *Yield groups—*						
Above 120 nuts	60·2	10·7	420·3	98·2	58·0	21
From 101–120 nuts .	61·1	10·4	394·9	97·0	57·8	24
From 81–100 nuts ..	60·0	9·6	406·4	99·2	58·8	16
From 61– 80 nuts ..	62·4	9·1	419 1	97·5	56·7	16
From 41– 60 nuts ..	58·9	10·4	418·5	99·9	58·1	14
40 and below 40 nuts ..	68·0	8·5	367·6	89·9	53·7	8
(ii) *Method of pollination—*						
(1) Cross	59·6	10·4	413·5	98·9	57·6	38
(2) Natural	62·6	9·9	410·4	97·2	57·4	34
(3) Self	63·1	9·1	389·5	94·7	56·6	27

Judged from the above data it is found that seedlings obtained by self-pollination and those obtained from low yielding groups particularly those yielding 40 and below 40 nuts per tree per year are less vigorous than the crosses, the naturals and the high yielding groups. Seedlings obtained by cross-pollination and those obtained from parent trees yielding above 80 nuts per tree per year can be regarded as the best.

(*c*) Inter-varietal crosses between Tall × Dwarf having given encouraging results, fresh crosses were made between promising world varieties to find out whether the progenies show hybrid vigour and combine desirable characters. The exotic varieties and forms utilized for the work were Cochin China, New Guinea, Philippines, Straits Settlements, Laccadive, Java, Fiji and Dwarf varieties. The area available for fresh planting being very limited only a few selected crosses were planted in 1943 and subsequent years at Nileshwar II. From a study of the vegetative characters it may be stated that the following crosses are vigorous :—

(i) Laccadive × Chowghat Dwarf.

(ii) Straits Settlements × Andaman Dwarf.

Coconut products—(*a*) *Copra*.—The copra content of the nut varies considerably in different seasons and localities. The average copra content per nut on the West Coast is about 1/3rd lb. and 6,250 nuts generally yield a ton of copra. In Godavari and Mysore about 8,500 nuts are required to make a ton of copra. But in Ceylon and Malaya 4,800 and 4,200 nuts respectively yield a ton of copra. In order to make copra, the nuts are husked, broken into halves and dried in the sun for four or five days. The best grade of copra is obtained by sun-drying for about seven days; the copra made during the rainy season by smoking over a fire place is of inferior quality being sooty, and the oil expressed from it being coloured and smelling of smoke.

(i) *Factors which affect copra content.*—(1) The age of the palm does not affect the copra content of the nut.

(2) The yield of copra per nut is high during the summer months of February to May because of the large sized nuts harvested during the period, and it is low in the months of August to November.

(3) The annual variation in the outturn of copra per nut is negligible.

(4) The yield of copra is not related to soil types.

(5) Manuring was noted to increase the copra content per nut and this effect was marked with complete manures (N.P.K.) cattle manure and green manures.

(6) The copra content of the nut appears to be an inherent, varietal character. High yielding eco-types had less copra per nut than poor yielders.

(7) Copra is generally made both from nuts immediately after harvest or after storing them for varying periods. Storing the nuts for two or three months gives three to five per cent more copra. During storage a large percentage of immature nuts get spoilt than the mature ones. Storing for nine to twelve months is practised in the manufacture of ball copra when the loss due to spoilage and germination is about five per cent.

(8) The relationship between the copra content of the nut and the various morphological characters studied, revealed that the copra content of nuts from trees having compact and spherical crowns, was more than that from trees with loose spherical crowns, and that spheroid nuts contained the largest and the linear nuts the minimum quantity of copra. The other characters studied, viz., length of leaf, length of leaf attachment, length of petiole, rate of leaf production, production of female flowers and colour of the nut were not related to the copra content. Thicker petiole was associated with higher copra content of the nut.

(9) The maximum copra content was obtained from fully mature nuts, i.e., 12 months after pollination. Harvesting when they are 11, 10 and nine months old reduced the outturn of copra by six, 16 and 33 per cent respectively.

(10) The quality of copra was good in 11 and 12 months old nuts and poor in less mature ones.

(ii) *Copra kiln.*—In 1945 a model, 10-acre Malayan copra kiln, was constructed with cheap materials like mud and coconut leaf thatch at a cost of Rs. 10 with the object of producing copra during the rainy months when sun drying is not possible. The quality of the copra produced was fair and the cost of manufacturing it from 100 nuts was Re. 0–11–9 as against Re. 0–4–5 required for sun-drying. Copra was ready in four days of ten hours drying per day. Each charge of 50 nuts required 400 coconut shells (halves) for fuel.

(iii) *Copra storage.*—When well dried copra is stored in dry and well ventilated rooms there is practically no loss. But various types of moulds grow on copra which is not well dried and

and white (*Rhizopus* sp.) moulds were the common ones though other species have been noticed occasionally. A study of the development of free fatty acids in mould-free copra inoculated with the pure strains of five different moulds and kept under optimum conditions for mould development showed that *Aspergillus niger* was the most damaging followed by the yellowish white mould Rhizopus nigricans. Least damage was caused by the yellow-green mould *Aspergillus oryzæ*. Copra damaged by moulds usually gave high percentage of oil. In the case of *Aspergillus niger* infection, within a period of 50 days, 33 per cent of non-fatty portion was found lost, but the loss in oil was only three per cent. This differential action is responsible for the apparent increase in the oil percentage. Mould attack is confined to the inner surface of copra which contains comparatively less percentage of oil. The quality of deteriorated copra can be improved through storage in well ventilated godowns. The actidity is then reduced and moulds fall off as dust. If storage for a long period is necessary, copra should be periodically dried in the sun.

(*b*) *Coconut oil.*—The oil is obtained by crushing copra in country *chekkus*, rotary mills or expellers. The average oil content in the West Coast copra is about 70 pepr cent by either extraction but only 54—58 per cent is extracted by *chekkus* and 62—65 per cent by mills. Oil extracted from good copra is clear, and keeps longer in storage without developing rancidity.

(i) *Factors which affect oil content.*—(1) No correlation was found between the age of the palm and the oil content of the nut.

(2) The percentage of oil in copra is high during the cold season—November to February—when the production of copra is low. But the outturn of oil per nut is high in the summer months due to the increased outturn of copra per nut during this period. Based on this finding it is recommended that nuts harvested in the summer months be preferred for copra-making to those of the cold months which may be disposed of as whole nuts.

(3) Annual variations in the percentage of oil and variations due to soil types are negligible.

(4) Application of manures, especially ammonium sulphate, increases the yield of oil.

(5) The relationship between the oil content of copra and the morphological character of the tree was studied. The percentage of oil showed a tendency to increase as the length of leaf, length of petiole, length and breadth attachment of petiole to the trunk and the thickness of the petiole increased. Rate of leaf and female flower production, type of the crown and colour of the nut had no relationship with the oil content of copra.

(6) Oil percentage in the immature nuts is generally more by about two or three per cent, but the total quantity of oil is low as the copra content for such nuts is also low when compared with mature nuts. Thus the loss of oil per nut is six, 16 and 33

per cent in 11, ten and nine months old nuts. There is a decrease in the oil content of copra when 11 and 12 months old nuts are stored, while it increases in the nine months old nuts.

(7) There is not much difference in the free fatty acid content of oil obtained from mature and immature nuts but if the nuts are stored for one or two months before making copra the acidity increases rapidly in the case of immature nuts.

(8) The copra of medium bearers appears to have the maximum percentage of oil.

(ii) *Storage of oil.*—Preliminary studies on the deterioration of coconut oil as affected by containers used for storage were carried out with *chekku* and mill oil. It was found that tins appeared more suitable than coloured transparent bottles. Oil stored in blue transparent bottles deteriorated at a much faster rate than oil stored in amber, green and colourless bottles. Mill oil was in general found to possess better keeping quality than *chekku* oil. A tendency for a slight reduction in the value of the refractive index during storage was in evidence.

(iii) *Grade standards for copra and coconut oil.*—As a preliminary to the drawing up of grade standards for copra and coconut oil a detailed investigation of the various quality factors of copra and oil samples collected from important producing and assembling centres in India was undertaken at the instance of the Indian Central Coconut Committee. A total of 125 samples of milling cup copra, 94 samples of edible cups, 80 of edible balls, 69 samples of mill oil and 34 samples of *chekku* oil were analysed. The important observations made are the following :—

Milling cuup copra.—The West Coast cup copra appeared to be better than the Travancore cups in all respects. July seasonal samples had a higher oil content and acid value than the other three seasonal samples.

Edible cup copra.—The oil content and acid values of edible cups were slightly lower than those of the milling cups from the same region. Among the varieties in the edible grade 'Madras Nottam' had a lower oil content and acid value than 'Dilpasand' variety. The samples from different territories registered definite differences. The Godavari samples were generally smaller than those of the other three regions (West Coast, Travancore and Tanjore). The acid value and oil content were higher in the case of the West Coast and Travancore samples than those of the other two regions.

Ball copra.—There was variation in size only among the different grades. The other quality factors did not exhibit any marked differences.

Coconut oil.—*Chekku* oil samples had, in general, a higher acid value, higher refractive index, and lower saponification value than the mill oil samples. From the available data it was not possible to draw definite conclusions on the seasonal and tract variations.

Based on the results of analyses, suitable grade standards have been suggested for copra and coconut oil.

(*c*) *Coconut cake.*—About 35 per cent of the weight of copra crushed remains behind as cake. This is used as a concentrated food for cattle on the west coast. In the Madras State the demand for the cake outside the west coast is negligible.

(*d*) *Coir.*—Coir is the fibre obtained by beating retted coconut husks. A variety of articles such as yarn, ropes, mats, brushes, bags, etc., are manufactured from the fibre. Generally green husks are preferred for coir manufacture as they give fibre of good colour. The husks are heaped in pits near saline back-waters for retting, which is complete in about nine to ten months. The fibre is separated by beating with wooden mallets. The outturn of fibre from the husk of 100 nuts is about 17 lb.

(i) *Coir studies.*—With a view to finding out the outturn and quality of coir from nuts of different maturity an experiment was started in 1939. Nuts of 12, 11, 10 and 9 months of age were utilized for the study and the quality and the quantity of fibre obtained were studied. The results which are summarized in the following indicate that 11 months old nuts are the best for coir making :—

(1) There was not much difference in the weight of coir obtained from the nuts of the different maturity.

(2) Best coloured fibre was obtained from the husks of 10 and 11 months old nuts, while 12 months old nuts gave fibre of dark colour.

(3) Fibres from 12 months old nuts were significantly shorter than those of 10 and 11 months old nuts. No perceptible differences were noted in respect of thickness in the different age groups.

(4) Yarn made from the fibre of the four age groups showed that the tensile strength was the lowest in the 12 months' old nuts and highest in the 11 months group.

(5) Since retting for a period of 12 months under conditions obtaining at Kasaragod was found to result in dark coloured fibre due to over-retting, particularly in the younger age groups, retting for 9 months was recommended to be the optimum. Differences in tensile strength due to varying periods of retting were negligible.

(ii) *Resistance to decay of coir yarn.*—Coir yarn obtained from the husks of four age groups was retted for 6, 9 and 12 months and the coir obtained was twisted into yarn. This yarn was subjected to four treatments, viz. :—

(1) Immersed in sea water, (2) immersed in fresh water, (3) exposed to sun and rain and (4) kept in shade, and the tensile strength of the yarn so treated was determined at the end of three, 6, 9 and 12 months of treatment. The results indicated that the reduction in tensile strength is lowest in yarn kept in shade, and maximum in yarn exposed to sun and rain, and the longer the period of treatment the greater is the decay.

(iii) *Commercial grades of coir yarn.*—Coir yarn marketed in the different parts of South India is found to vary considerably in quality. Twenty-four samples of important grades of yarn obtained from representative centres were studied. It was found that there was no marked difference in the length of fibres in the yarn obtained from the different centres. Travancore samples were finer and thinner in quality. Samples from Godavari were generally of poor quality being coarse and of deep brown colour with considerable quantity of pith attached to the fibres. (Plate 44.)

(iv) *Maturity of the nut in relation to copra, oil and coir.*—Harvesting of nuts before they are fully mature, i.e., 12 months old, is the usual practice in the back-water areas of the west coast, where coir making is an important cottage industry. This is because green husks obtained from immature nuts are supposed to yield good quality and quantity of fibres and consequently such husks fetch a better price. Copra, oil and coir are the important products which bring in a good return to the coconut grower. An investigation into the quality and quantity of copra, oil and fibre from nuts of different maturity was undertaken. As already stated earlier harvesting of 11, 10 and 9 months old nuts resulted in a loss of 6, 16 and 33 per cent of copra and oil. From the point of view of quality and quantity of coir, husks of 11 months old nuts are the best, 12 months old husks being definitely unsuitable. Taking all factors into consideration harvesting nuts when they are 11 months old is the best in tracts where coir making is an important industry. The harvest of less mature nuts is definitely undesirable as the loss in copra and oil is considerable and there is nothing to be gained either by way of increased outturn or better quality of fibre from such immature nuts.

Tapping.—Tapping is the process of drawing the sweet juice from the spathes (unopened inflorescences) of the coconut. Three weeks from the commencement of tapping the juice begins to flow and lasts for about a month. There are two seasons for tapping, i.e., April to October and November to March and generally the trees are tapped for one season only. Vigorous trees may be tapped rarely for two years continuously. All the spathes produced during the period are tapped successively.

(*a*) There is considerable variation in the yield of juice from day to day, season to season, spadix to spadix and tree to tree. The average yield of juice per tree is about 3¼ lb. per day and the maximum quantity is obtained in the third month of tapping but the minimum which is dependent on the season of tapping is recorded in the months of September to December. The total yield of juice per spadix varies from 3½ to 7½ gallons; yields are high in May-June and low in October-November season.

(*b*) Continuous tapping of trees under dry cultivation for more than six months may not be profitable as there would be large variations with frequent low yields. For dry localities tapping should be confined only to the rainy months of the year.

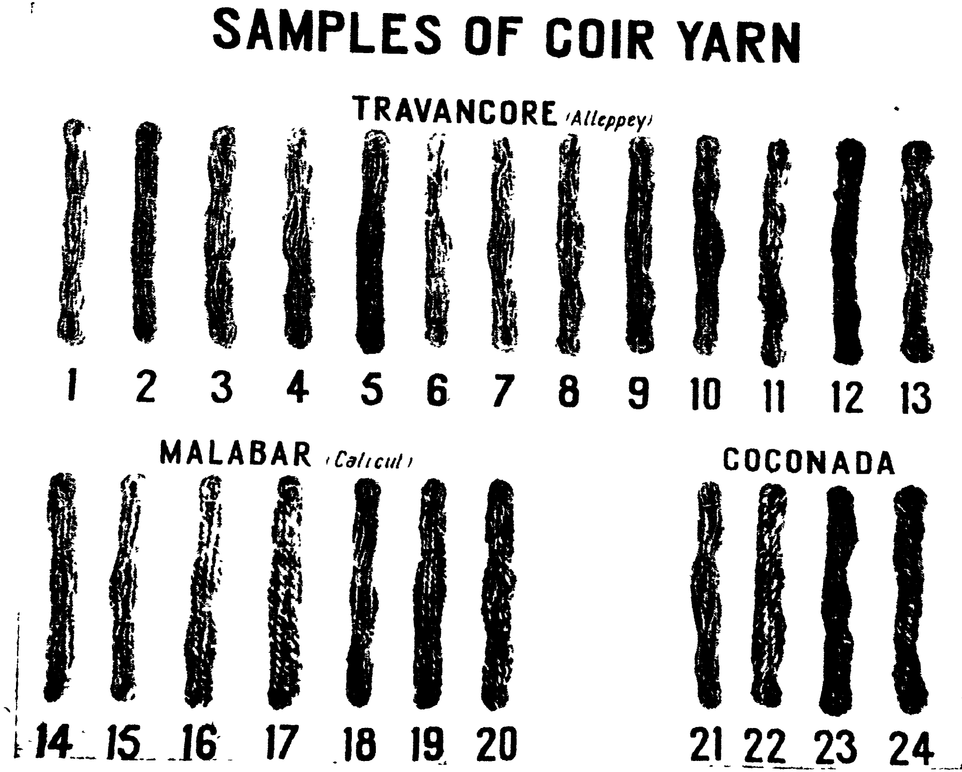

Plate 11.—Commercial samples of coir yarn.

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(*c*) Correlations worked out revealed the existence of high relationship between the yield of juice and the number of nuts in a tree.

(*d*) Tapping increases the yield of poor bearers only in the post-tapping period and this effect lasts for about four years.

(*e*) Forms Laccadive ordinary, Andaman ordinary and Laccadive small were the best for tapping, the yield of juice being nearly double that of the west coast tall variety. Andaman giant, Siam and Spikeless did not yield any juice in spite of continued tapping.

(*f*) The outturn of jaggery varies from 12·4 to 15·8 per cent of the juice. Generally large outturn of jaggery is obtained in February-March, and it is low in July-August.

(*g*) Effect of tapping on trees producing barren nuts was discussed in an earlier section.

Pests and diseases.—The details of the pests and diseases affecting the coconut and their control measures are dealt with in Chapters 22 and 23.

Part played by the Coconut Research Stations.—Research work on the important problems pertaining to the coconut has been in progress in Madras for nearly two decades and results of considerable economic importance have been achieved. This State can well claim and be proud of the fact that it has been a pioneer in coconut research among all the coconut growing countries in the world.

It may be seen from the foregoing sections that a detailed study of the palm characters and the anatomical studies have given valuable information. The factors affecting growth, yield, etc., have been studied and the results of considerable practical value have been obtained. Cultural experiments have shown the importance of regular cultivation of the coconut gardens. Manures required to obtain maximum yields have been determined and their economis dosage fixed. A schedule of the proper cultural and manurial operations for a coconut plantation has been drawn and by adopting it the yields at the coconut stations have been considerably increased and maintained at a high level. A new green manure crop eminently suited for cultivation in coconut gardens has been isolated. The standard of selection of parent trees, seednuts and finally the seedlings and nursery practices were perfected after years of research. The Indian Central Coconut Committee has been adopting the standards fixed in the nursery schemes sanctioned in the different States. Improvement of the coconut by hybridization has been taken up. A collection and study of the exotic varieties of the coconut has been made, and economic types suited for propagation and breeding work were fixed. Much work has been done on the coconut products of commercial importance, viz., copra, oil and coir and the results achieved are of economic importance not only to the cultivator but also to the trade. Attention has also been bestowed on the control of the pests and diseases of the coconut.

Research is necessarily a continuous process. Though much work has been carried out, much more remains to be done. The cultural and manurial treatments advocated have not been tested in the other important coconut regions of the State, namely, the Circars and Tanjore district. These regions have numerous local problems which can be handled only by opening regional stations. The breeding work has to be intensified and the resulting progenies tested in the different tracts. Cultural and manurial experiments have to be conducted with a view to improving the present practices and devising more economical systems. Further research on the various problems still awaiting solution would yield practical results which should benefit the ryot and the State as well.

CHAPTER 8.

FRUITS.

Place of fruits in nations agricultural economy—Need for increasing area—History of fruit research in Madras—Fruit Stations, Burliar, Coonoor, Kodur and Aduthurai—Propagation of improved fruit plants—Fruit canning and preservation.

Work on individual fruits—The *Mango* **area, climate, soil, varietal introduction and trials—Off-season bearers—Standardization—Evolution of strains, selection, hybridization—Agronomic experiments—Inarching, side and root grafting, budding, top-working—Comparison of methods—Hormone treatment—Pruning—Cropping and harvest.** *Citrus fruits*: **Production, area and climate, soil—Varietal introduction and trials—Sweet orange—Mandarin—Lime—Lemon—Pummelo—Grape fruit—Citron—Kumquat—Sour orange—Vadlapudi—Strains evolved—Rootstocks—Nursery practices—Irrigation, manuring—Harvest—Yields—Fruit products.**

Banana: **Production—Importance—Varietal introduction and trials—Agronomic work—Transplanting and other cultivation practices—Ripening, storage and products—Varieties in Madras State.**

Grape : **Area, climate, soil, cultivation and agronomic trials.** *Fig*: **Varietal introduction and trials.** *Pomegranate*: **Varietal introduction and trials.** *Papaya* ; **Varieties, strains evolved, selection, hybridization, agronomic trials, storage and products, varietal and other trials on miscellaneous fruits, sapota, jack, pineapple, guava, zizyphus, muskmelon, water melon, mangosteen, durian, litchi, avacado pear, carambola, rose-apple, starapple, gooseberry, bread fruit, woodapple.** *Hill fruits* : **Evolution of strains and agronomic trials, apple, plum, pear, peach, persimmon, strawberry, Cape gooseberry, passion fruit, apricot, and walnut.**

Fruit growing is one of the most fascinating branches of agriculture. Besides being remunerative, it contributes in a measure to satisfy the aesthetic requirements of rural life by the live touch with individual plants, dear to the grower by their attractive appearance and exquisite taste of the fruits. Fruits are well known as protective foods supplying valuable vitamins and minerals, besides pectin and cellulose. Most fruits yield much more from a unit area than several agricultural crops and thus help in meeting the food shortage in the country as subsidiary foods.

Thus an extension of the area under fruits is very important and will promote the country's health and wealth. Besides, it will open out the way for several dependent industries which can contribute to the prosperity of the nation.

Fortunately, Madras has been favourably placed for fruit production in India not only in extent and production but also in

excellence of quality. The fruits grown, consist of many distantly related kinds and varieties. They are grown in a wide range of conditions of climate, soil and water-supply in tropical and temperate areas in the hills as well as in the plains and as rain-fed or irrigated crops.

This favourable condition for many kinds of fruit, is one reason for a very large increase in area and production in recent years. There is great scope for improving the fruit industry especially in respect of mangoes, citrus, banana and other tropical fruits.

But the fruit growing industry in South India has also its limitations. Most of our fruits are produced from seedling groves which are highly variable. Owing to the indiscriminate choice of the variety and the lack of selection of the parent tree by most growers the production of choice fruits is low and has led to high cost and scarcity. Planting orchards in uncongenial sites has often been the cause of many a failure as seen in the alarming decline of the seedling Vadlapudi oranges over hundreds of acres in the Circars. Added to this are the harmful cultural, manurial, irrigational and pruning practices which have been prevalent owing to ignorance and the lack of codified information of an authoritative nature at the disposal of the growers.

It has been the endeavour of the department to obtain knowledge through research and impart advice and guidance to growers on the introduction of new kinds and varieties of fruits, the correct propagational technique, scientific methods of cultivation, harvesting, transporting and preserving of the several fruits.

Fruit investigation in Madras may be said to have taken its beginning when the Burliar Fruit Station in the Nilgiris was opened in 1871, followed later by the establishment in 1900 of the Fruit Station at Kallar at the foot of the Nilgiris. Both these stations were mainly intended for variety testing, i.e., to find out the kinds and varieties of fruits, spices and other horticultural crops of possible economic value that can best be grown under the humid tropical conditions which exist in the lower elevations ranging from 1,400 to 2,500 feet above mean sea level in the hilly tracts of South India. During their long period of existence, they have provided a trial ground for almost all kinds of fruits, spices, beverage and other plantation crops peculiar to these elevations.

Work at higher elevations was taken up when the Fruit Station at Coonoor was started in 1920 primarily to test the suitability of temperate fruits and other horticultural crops to the elevation of 5,500 feet above sea level. As a further step, detailed scientific investigations were also carried out on the various aspects of fruit like pruning, training, thinning, manuring, other orchard practices and several propagational methods.

During 1930 a scheme for opening two fruit research stations—one for the hills and the other for the plains—was submitted to the Imperial (now Indian) Council of Agricultural Research for sanction. The object of the station on the hills was extension of

a commercial scale of improved hill fruits from Coonoor and research thereon. The object of the station on the plains was mainly to improve the major fruits such as mango and citrus in quality and yield and for other miscellaneous work like control of insect pests and improvement of marketing.

The Fruit Sub-Committee recommended in 1931 that the plains scheme was the more important and should be proceeded with for the present with a grant of Rs. 66,064 to the Madras Government who accepted the grant and opened the Fruit Research Station at Kodur in 1935.

The station comprised initially an area of 50·53 acres and later an area of about 15·82 acres was acquired in a separate site in 1948 for the extension of certain rootstock trials. It is situated in the village of Anantharajupet, Rajampet taluk, Cuddapah district, and is in the heart of the citrus and mango tract.

From the inception of this station till the end of 1943, the work consisted mainly in investigations on the propagation of the main fruits, multiplication of plant material, lay-out of the several long-range experiments and collection of primary data. After 1943 the scientific activities were enlarged to growth studies, yield performances, rootstock trials, orchard practices and other subsidiary experiments of interest.

The Sub-Committee for Agricultural Development of the Provincial Economic Council, recommended the extension of fruit research in more areas. In September 1937 Government started experimental fruit culture at the Agricultural Research Stations in Anakapalle and Guntur. The latest addition to fruit research is the Banana Research Station opened in Aduthurai in June 1949 under a scheme sanctioned by the Indian Council of Agricultural Research.

PROPAGATION OF IMPROVED FRUIT PLANTS.

In this State as in the rest of India, the importance of propagation of plants from selected trees is not adequately realised except in Government nurseries. Partly due to this fact, and partly because of the difficulty experienced by the nurserymen in general in securing scion material from best trees, the propagation of plants is being carried out indiscriminately, bringing about progressive deterioration in the bearing and other desirable qualities of the trees planted in the orchard and in the uneconomic condition in many plantations.

Often the practice of selling plants under false varietal names is unfortunately widely resorted to, and the grower has to gamble for the purchase of fruit plants. Instances are numerous of the keen disappointment of the growers at finding out after seven or eight years of waiting, that the plants nursed for such a long period were neither true to the type nor profitable bearers. In the case of permanent crops like fruits, such disappointments did

irreparable harm and created in large-sized gardens considerable loss to the growers.

To remedy this defect, and to improve the fruit industry the Fruit Specialist recommended in December 1936, that a few nurseries be opened in representative tracts by the Government, for the sale of reliable plants of good parentage at a reasonable cost to help the establishment of the future orchards on a more secure and profitable basis. The Government sanctioned in 1938 the opening of Departmental Fruit Nurseries at Kodur and Taliparamba for one year. Both the nurseries have been very popular. A number of advance indents for plants were registered and several nurseries have sprung up in their vicinity, employing largely the technique evolved at these stations.

FRUIT CANNING AND PRESERVATION.

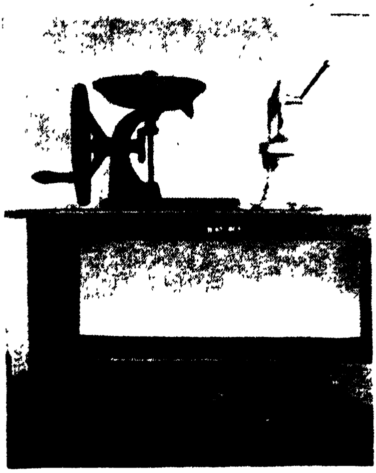
It is well known that some kinds of fruit are of indifferent or inferior quality, and do not therefore find a ready and profitable market. Even among the superior varieties and types of fruits, the indiscriminate raising of plantations has made it difficult in the peak period to dispose of the produce raised at such centres. Alarming fall in prices occurred in some of the extensively grown varieties also, when the production became surplus in pre-war years.

For utilizing such surplus, the canning and fruit products industry offers a suitable and profitable outlet.

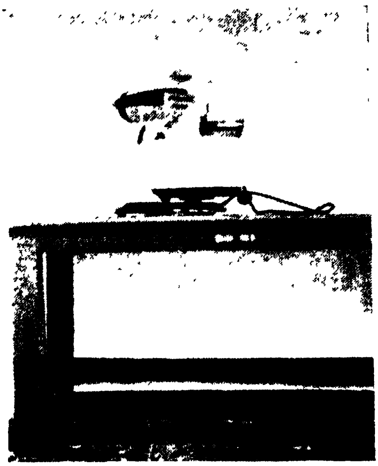
Such a step is also necessary to off-set the increasing imports of fruit products into the country and meet from our supplies the increasing demand for fruit products of standardized quality. As in other States of India, the consumption of synthetic beverages of no dietetic value in Madras is very large and there is every scope for diverting this demand towards fruit beverages of more healthful qualities in the form of juices, cordials, squashes and carbonated fruit drinks.

There is scope for mango, banana and citrus products, to find a ready sale in South Indian markets. These fruits are different from those grown in other parts of the world and therefore free from competition from products manufactured abroad. Further the cost of production of mangoes and some citrus and bananas raised under rain-fed conditions in South India is so low that the produce from these is likely to be available for industrial utilization at competitive prices. These various factors provide very favourable conditions for the development of these and other fruit products in Madras provided the quality of products is improved and standardized. The need for the development of canning and fruit product industry in this State has been realized both by the Government and by some of the industrialists. The Government have agreed to give State-aid to the "India Canning Industries, Limited, Vijayavada," which is manufacturing canned mangoes

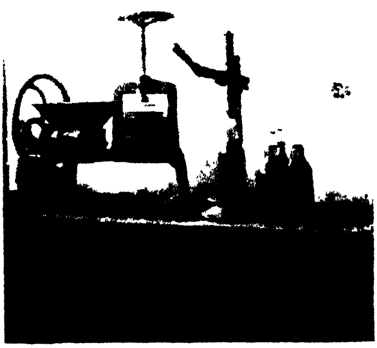
Plate 45. - Some equipment of the Fruit Products Research Laboratory, Kodur.



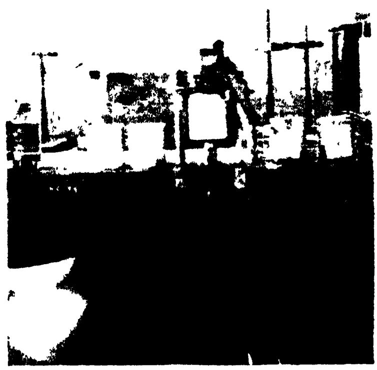
Hand juice extractor.



Mixmaster juice extractor



Juice press and crown corking machine.



Automatic can sealing machine

Jams, squashes and canned fruit.

and fruit squashes of different kinds. A very large company, probably the largest in India, known as the "India Fruits, Limited," has also been floated near Rajahmundry. One large factory near Calicut and about four other factories on a smaller scale have also commenced work, while a number of concerns are being started for the manufacture of fruit products.

Trials on the canning of certain fruits and preparation of certain fruit products have been in progress at Kodur from the year 1937 and some trials were also conducted formerly at the Government Fruit Preservation Institute, Coonoor.

Experiments carried out at Koduru indicated that Madras had many facilities for the manufacture of a variety of fruit products, which if developed could be of very great benefit to the fruit growing industry not only in this State but also to some of the neighbouring regions. Several enquiries have been made from time to time for information on the technique of manufacture of products from various fruits grown in this State and requiring technical guidance. To meet this pressing need, the Fruit Products Research Laboratory was sanctioned in 1942 and regular work started with the appointment of a Bio-chemist in May 1943 at Kodur.

Although the most important fruits locally available were limes, lemons, oranges and mangoes, research work was extended to other fruits also like pineapples, guava, hill fruits and wild fruits such as woodapple, *Carissa carandas* and jaman fruit. The preliminary results being very encouraging, steps were taken to secure large scale canning, juice and jam machinery from abroad, and introduce a number of changes into the methods and by taking up work on newer aspects. Several of the products standardized in the Fruit Products Research Laboratory have been released for sale in a limited way to gauge public opinion which has been quite favourable. Products have been sold locally at Madras and at various exhibitions throughout the province. As a result of this developmental work, numerous enquiries were received from interested persons regarding processes, economics, advice and guidance in starting small scale fruit preservation concerns in different parts of the Presidency. To meet, to a certain extent, the demand for trained personnel for the industry, a three months' course of practical training in fruit canning and preservation was started in 1945. Twenty-three candidates have undergone this training so far and some of them are already in the industry.

Public interest in fruit preservation has been created through practical demonstrations, radio talks and popular publications. Recently, five lady fruit preservation demonstrators have been employed to give practical demonstrations on fruit preservation at girls' schools and colleges, women's institutes and clubs, etc.

The Fruit Products Order, 1948, which is an enactment of the Government of India was handed over to the Agricultural Department for efficient administration from March 1949. The

object of this order is to improve the hygienic conditions of the fruit preservation factories in India and to see that the products are up to prescribed standards in every way. Since taking over, much headway has been made in achieving these main objects.

Based on the results of work done so far it is proposed to manufacture certain standard products like canned mangoes, orange squash, lime squash, lime juice cordial, simple as well as mixed fruit jams, passion fruit squash, etc., on a fairly large scale using commercial scale equipment. The major part of the machinery has been got already and this will be installed soon.

Soil Survey for Fruits.

For the last two decades a definite trend towards extension of orchards has been noted in this State on account of increase in demand, due to war conditions. Orchards have been planted indiscriminately in all available sites. A scheme was, therefore, sanctioned early in 1946 for conducting soil survey in the Ceded Districts for fruit development where the extension was most rapid. An account of this soil survey work will be found in the chapter on soils.

The work done on individual fruits is summarized below :—

Mango (*Mangifera indica*).

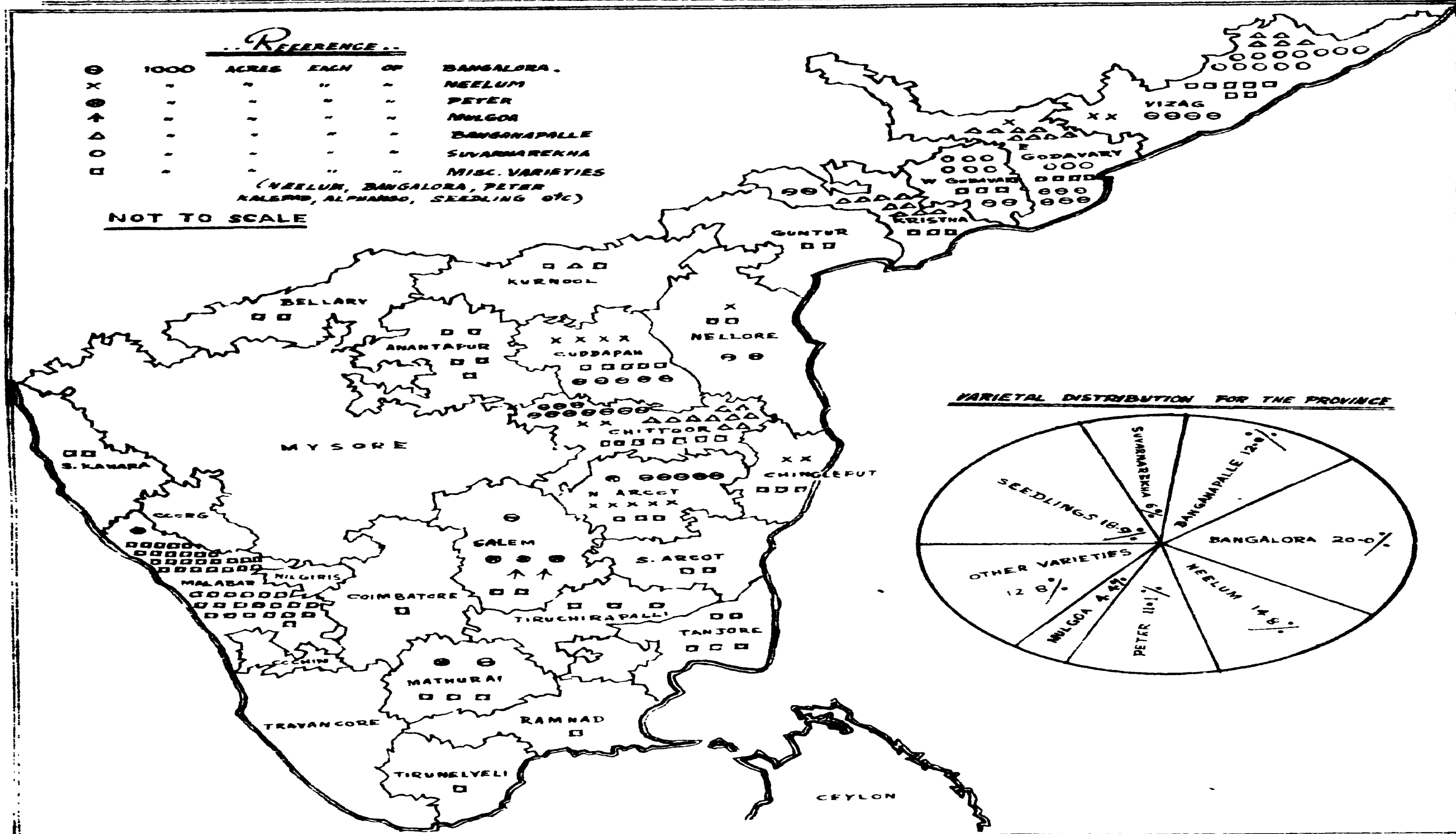
Mango is the fruit *par excellence* of India. Owing to its high adaptability to different types of soils, the cheapness of its culture, its high yields and extremely delicious table qualities, it has been cultivated extensively in our country from time immemorial.

Production and importance.—The area under mango in the State of Madras is roughly 250,000 acres or about 50 per cent of the total area under cultivated fruits. The annual production is approximately 855,000 tons of which about 21,200 tons are exported outside the State mainly to Bengal, the Punjab and Bombay and in a smaller measure to Burma, Ceylon and Straits Settlements.

The chief centres of mango production in the State are the districts of Malabar with 50,000 acres, Visakhapatnam with 40,000 acres, East Godavari with 30,000 acres, Chittoor with over 25,000 acres and North Arcot and Cuddapah districts with about 14,000 acres each. (Plate 46.)

Climate and soil.—Mango is found to grow even at elevations of 4,000 feet above sea level, but beyond 3,000 feet, trees are not of commercial importance, but are mainly grown as a shade for some spice crops. Heavy rains during the fruit maturing period, which occur in the west coast at the commencement of the south-west monsoon, are destructive to the mango crop, and this is one of the reasons why late varieties fail to mature successfully in that part of the country. In general, dry weather and cloudless sky at flowernig and fruit ripening periods help crop size. Studies

VARIETAL DISTRIBUTION IN THE MAIN MANGO GROWING TRACTS IN MADRAS STATE



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at Kodur on four varieties of mango have shown that dry summers help the shoots to get the desired rest period for a successful fruit bud initiation, and that a dry season preceding the emergence of blossom, which will induce early cessation of growth, gives a good crop. The early production of mangoes in the west coast is partly due to the early cessation of growth, owing to the very low rainfall in the north-east monsoon. The off-season production of mangoes in parts of Tamilnad is similarly an effect of the seasons. There are a few varieties in South India which can and do produce up to five successive crops of flowers if the previous ones are destroyed due to ravages of nature.

Mango adapts itself to a wide range of soils in the Plains. It has, however, a preference for deep well-drained soils which are moderately fertile. In highly fertile soils it has a tendency to put on luxuriant vegetative growth at the expense of fruiting. In poor stony soils, the trees are often dwarfed, and appear very sickly, though usually bearing a crop heavier than what they seem capable of. Occasionally trees are met with on apparently rocky soils attaining huge size and yielding well. This is due to the uniform texture of the soil underlying the interrupted bed of rocks above, through which the roots penetrate. Mango is, however, sensitive to sudden variation of soil texture within small depths. This is the reason why in many soils where heavy sub-soils are overlaid by a layer of lighter soil, mango has often failed. Mango has been cultivated in almost pure sand along the coast. Under such conditions liberal manuring and copious watering, till the roots strike a moisture layer, are very important. Except under such circumstances mango is not usually irrigated because of the high foraging capacity of its roots.

Varietal introductions and trials—(*a*) *Polyembryony*.—A very large number of mango trees is still raised from seed. Being cross-pollinated, the plants raised from seeds of a particular variety are almost always sure to turn out to be different from the parent. In certain varieties, however, a single seed of mango gives rise to more than one seedling only one of which is likely to be the result of sexual union. Often the sexual seedling is smothered by the asexual seedlings. Such asexual seedlings which arise from the nucellar tissue of the embryo are true to the mother plant in varietal characteristics in the same manner as a plant raised from a cutting or a layer from the mother plant. This phenomenon, called *polyembryony*, has been noted in about ten races of mango in our State of which *Olour* of the west coast is best known. This variety has, therefore, maintained the purity of characters through generations of seed propagation. But in the case of monoembryonic varieties, the choice qualities cannot be preserved and the seed-propagated plants cannot be called varieties. Occasionally a good seedling may be perpetuated by vegetative propagation as a new variety. Such a process having taken place through the ages, there are over 350 varieties of mango in our State alone. But not all of them are of exceptional merit; nor prolific yielders; nor

regular bearers and, therefore, not all suited to commercial orcharding. A study of detailed performance undertaken in a remunerative orchard at Kodur having 1,632 trees showed that out of the 25 varieties, *Neelum* and *Bangalora* were the only two which accounted for the favourable balance sheet of the orchard.

(*b*) *Off-season bearers.*—In addition to the varieties reputed to be off-season bearers included in the variety collection, some varieties as well as grafts from trees that have exhibited this character have been collected and planted at the Fruit Research Station. It was revealed that the so-called Baramasi types were not dependable off-season bearers. It is also reported that the grafts from individual tree selections have 'failed to produce regular off-season crop of considerable bulk as expected.' Owing to the peculiar seasonal conditions existing in the southern parts of Tamilnad, several varieties grown in this tract give an off-season crop of appreciable size. *Peter* and *Baneshan* have been often observed to produce bloom in the off-season at Coimbatore. At Kodur, *Ambalavi*, a variety from Ceylon, had produced five crops of blossom between September and the following May, and *Neelum*, *Kintalavanipeta*, *Manoranjan* and *Willard* produced three crops of blossoms. It is also reported that the clonal progenies of an off-season bearing tree at Tenali behaved like the parent in the same district. The facts seem to point out that off-season bearing, though mainly a varietal character, is induced by favourable seasonal and climatic influences.

The variety testing and selection of varieties for an orchard can only hold good for that particular region, as the regions of South India vary so widely in their climate. For a knowledge of the performance of standard varieties in the several orchards spread over the country, a survey type of investgation to determine varietal performance under a multiplicity of conditions from parents of known performance is necessary. Accordingly a scheme was sanctioned appointing a whole-time assistant for the work for a period of one year from February 1949. The survey proved helpful in bringing out the most serious defects in the prevalent methods of establishment, stocking an management of orchards and in formulating a set of guides to fruit producers to avoid such defects. It was also possible to recommend different varieties and kinds of fruits suited to each region. For instance, although the mango appeared to be thriving in a rainfall range from about 20 inches to 150 inches per annum, there was difference in respect of varietal suitability. Varieties like *Bennet Alphanso* were suited to high rainfall areas, while mid and late season varieties were suited to the rest of the State.

(*c*) *Standardization of varieties.*—Selection and distribution of varieties and parent trees would be of little value, however, if they do not conform to a standardized description and nomenclature. Chance seedlings perpetuated as clones have often been given fanciful varietal names by nurserymen. At present a

Plate 47.—Mango grove.

(*A layout at **Fruit** Research Station, Kodur.*)

great deal of confusion prevails in the names of varieties, the same variety going often under several synonyms in the different mango growing tracts, while some distinctly different varieties are brought under one and the same name. The supply by nurserymen of plants under wrong varietal names leads consequently to a great deal of avoidable waste of efforts and money. In order to provide a uniform description of varieties and nomenclature in the mango, Government sanctioned in 1936 a scheme for taxanomical studies of fruits. These studies have enabled not only the accurate description of all the commercial mango varieties of South India but also the selection of the most suitable for extended cultivation in each region. A monograph on the classification and nomenclature has been prepared which is being issued as a separate publication. The key drawn up helps to distinguish varieties at all times of the year and from the nursery to the bearing stage in the procurement of genuine nursery stock.

Evolution of strains and varieties—(*a*) *By selection.*—Varieties originated in mango as chance seedlings in nature when they were spotted and perpetuated by vegetative propagation. All the present trees of any variety are thus supposed to have originated as clones from a single parent tree of that type which might have arisen as a chance seedling. The original parent trees of *Mundappa* in Mangalore and *Chinna Suvarnarekha* in Visakhapatnam district are said to be still alive.

Among the monoembryonic seedling mango trees planted at Kodur, some seedlings of appreciable qualities have been spotted and have been selected for perpetuation. They are K.O.'s 22, 16, 11, 7 and 6 of which the K.O.s 22 and 11 were best.

The clonal propagation of the varieties is likely to lead several people to think that once a variety is chosen, grafts from one tree are as good as those from any other. The accepted theories of heritability of characters through genes lead us to think that this should be so. But observations on several kinds and varieties of fruits in different parts of the world, however, indicate that there can be variability within the clones which will be transmitted to their vegetative progeny. The orchard efficiency analysis in an orchard near Kodur has also brought this out clearly. During the four years 1936–39, only one single tree out of 1,632 bearing ones produced heavy crop of flowers in all the four years consistently. Heavy fruiting trees formed only 2·6 per cent of the orchard, while the percentage of trees that put up a poor performance in all the four years was as high as 83·0 in *Andrews*, 84·2 in *Mulgoa*, 39·5 in *Bangalora*, and 35·5 in *Neelum*. On the other hand, every single tree of all the vegetative progeny of a single selected tree of *Neelum* and another selected tree of *Bangalora*, yielded during the first three years of bearing. Besides, twenty *Himayuddin* grafts supplied from the Sugarcane Research Station, Anakapalle, in 1943 averaged 250 to 300 fruits per tree, which is a striking departure from the general performance of most of the trees of the variety, which is known to be a shy bearer.

These instances indicate that maintenance of tree records and selection of the parent trees on their basis will gradually eliminate the astonishingly large proportion of non-bearing trees that occupy our orchards consequent on the indiscriminate purchase of plants without ascertaining the parentage. At the Fruit Research Station, Kodur, individual records of over 100 varieties have been maintained with the purpose of propagating only the high yielding trees of each variety.

By hybridization.—If we were to depend upon the selection of chance seedlings for producing the 'ideal' mango variety, say, one having the taste of the exquisite *Jehangir*, the beautiful colour of *Suvarnarekha* or *Janardanapasand* and the prolificity and regular bearing nature of *Neelum*, it will take a very long time and the chances are that we may never come across one. To combine all these desirable characters now dispersed in a number of varieties, hybridization has to be undertaken. This work has been taken up at the Fruit Research Station, Kodur, since 1935. From the 13,523 crosses so far made, 98 seedling progenies resulted and have been planted out in the field for study of characters. Out of them 24 progenies have fruited so far. The following seven crosses have proved worthy of being multiplied as promising types :—

(1) *Neelum* × *Himayuddin* (3/1).
(2) Do. (7/5).
(3) Do. (9/3).
(4) *Neelum* × *Yerramulgoa* (2/11).
(5) Do. (2/13).
(6) *Chinnasuvarnarekha* × *Jehangir* (11/13).
(7) *Bangalora* × *Alampur Baneshan* (4/3).

Certain varieties tended to give a greater percentage of set with the pollen of certain other varieties, indicating the need for proper pollenizers. For example, *Panchadara Kalasa* appears to be a compatible pollenizer for *Neelum*, *Bangalora*, *Baneshan* and *Suvarnarekha*, and *Baneshan* for *Neelum*, *Bangalora* and *Jehangir*.

It was also observed that there were great variations in floral structures from variety to variety and of these shorter style length and lower ratio of style length to stamen length, seemed to be associated with better fruit set through open pollination. A positive relation existed between the percentage of perfect flowers and the number of fruits carried to maturity per panicle.

Parthenocarpy did not appear to be a common feature of mango and this fact coupled with the affinity of some varieties for the pollen of certain others indicates the need for further study regarding compatibility.

(*b*) *Other methods.*—The improvement or standardization of the quality of a variety by means of suitable rootstocks does not strictly come under the head 'evolution of strains'. But in horticultural crops which are propagated by budding or grafting, the effect of the rootstock on the yield and quality of the produce of a variety is so consistent that it is very important.

The usual rootstock used for mango is the monoembryonic seedling of unknown parentage. The stones are collected from anywhere and sown in the nursery. It is no wonder that large variations are found even amongst cloves of the same trees propagated on these non-descript seedlings.

Experiments conducted to minimize this variability resulting from the rootstock have shown a striking indication of the scion vigour on polyembryonic seedling rootstock, such trees showing conspicuously larger growth than those grafted on monoembryonic rootstocks.

A method of root-grafting has been developed to suit the mango which will reduce to the minimum the variability due to the rootstock by altogether eliminating the rootstock stem.

Shy bearing is invariably associated with the superior fruiting mangoes of South India. To find out if, through double-working and the employment of a regular high-yielding variety as the intermediate stem piece, yields could be increased in the ultimate scion, a small trial was initiated in 1940. Records of blossom and fruit crops have shown that on the basis of blossom crop alone, the double-worked trees display better performance than the single-worked trees in many varieties. The results with regard to fruit crop are as yet inconclusive.

Agronomic trials and experiments—Nursery practices.—Nursery is aptly called the cradle of the orchard. Even in selected parent trees, defects in the nursery technique might eventually produce plants which are too weak to bear any crop. The perfection of nursery practices is therefore a very important step in the progress of our fruit-growing industry.

Several experiments had been conducted at Kodur covering all the details of propagation and some of the more important results are summarized below :—

Inarching.—Inarching is the most common method of propagating the fruit in this State and is not likely to be superseded for a very long time to come because of the ease with which even a comparatively unskilled workman can graft by this method. So some trials have been undertaken at Kodur to make this method more economical and to increase the efficiency.

Sowing of mango stones with plumule pointing upward was found to produce seedlings with straight taproot and stem both of which features facilitate the inarching and root-grafting operations. Although shelled stone produced straighter taproot and stem than unshelled ones and also helped in the elimination of diseased or worm-infested stones, it was not advantageous because of poor germination and of the expensiveness of shelling. Grading of fruit or stone was not useful, as neither plant vigour nor germination was dependent on the size of the fruit or stone.

Transplanting six-month old mango seedlings with naked roots was found to be a feasible operation if done in January in shade after shortening the roots to nine inches. Defoliation of

mango seedlings about seven to nine days prior to their lifting from seed beds has been found to reduce the casualties. Placing of potted seedlings together in a trench and letting in irrigation water at an interval of three to five days is more economical than hand watering individual pots daily. Young seedlings of even four and a half months age can be inarched successfully. July to September was found to be the optimum and June the worst period for inarching Neelum.

It was found that the age of rootstocks did not materially affect the growth of the trees in the orchard, at least within the age group included in this trial, i.e., 10½ months to 16½ months. In a trial conducted at Taliparamba, the length of graft joint was found to be of no importance. The optimum period from the date of inarching to that of separation from scion parent varied with different varieties. *Rumani* required four months while *Neelum* and *Bangalora* required only three months. The separated grafts could be planted in the orchard in November–February immediately after. The usual method of inarching has also some disadvantages, the chief among them being that the parent trees could be close to the nursery. It is also not economical to pot-water all the rootstock seedlings attached to the tree at different levels. If devices could be perfected by which the scion wood could be carried to the nursery, it would be a great saving for the nursery men and eventually to the grower.

A device called the 'grafting pot stand' (plate 48) has been made at the Fruit Research Station, Kodur, which economised the cost of inarching by providing a cheap means of lifting the rootstock seedling to the scion branch.

The following gives the results of budding trials made at the Fruit Research Station, Kodur (plate 49):—

Flap budding.—This method gave a success of 62 per cent in 1937 on *Neelum* variety. The technique is the standard Forkert method.

Patch budding.—A success of 79·45 per cent was reported by this method.

Shield budding.—This method gave a success of 83·56 per cent on 12 months' old rootstocks with *Neelum* scions. All these methods have been successful with budwood preserved for three to five days after separation from the scion parent.

Side grafting.—The terminal shoots of past season's growth which have not yet become fully mature and assumed the greyish bark colour are selected and all leaves up to four inches from the apical end are removed while still on the tree, leaving about half an inch of leaf stalk. About a week later this shoot is severed and side grafted.

It has been found that the success of this method will be great when done in a season when there are no heavy rains, strong winds or intense sunlight using scion shoots of 0·5 c.m. diameter or over. The months of October and November have

Plate 48.—Grafting pot stand.

Figure shows how it is being used at various elevations—Kodur.

P. 327

Plate 49.—A good mango graft in pot. Fruit Research Station, Kodur. P. 328

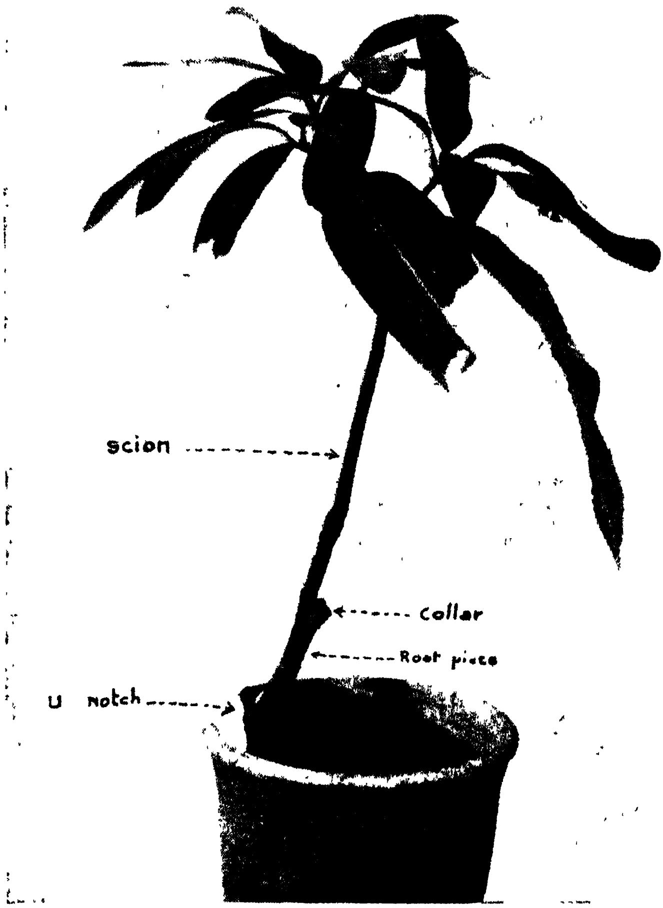

Plate 50.—A successful root graft of mango. P. 330
Fruit Research Station, Kodur.

therefore proved to be the best months though the operation could be done between July and December. At Taliparamba it was observed that tipping the rootstock soon after grafting induced earlier sprouting of the scion. Varietal influence on the success was also noted. At Kodur, *Jehangir*, *Himayuddin*, *Khadar*, *Baneshan*, *Mulgoa*, *Alampur Baneshan*, *Rumani* and *Neelum* gave a good take in September while in November and December all the above varieties recorded a lower take. *Peter* recorded a low 'take' in both the seasons. It was also found that scion wood obtained from long distances three to five days after separation from the scion parent could also be succesfully employed.

Root grafting.—The form of root grafting known as bench-grafting is not suitable for evergreens which have no dormancy. Therefore a novel method of root grafting by inarching has been perfected at Kodur. This consisted in lifting one-year old seedlings on a cool day in rainy season and potting them immediately close to the edge of the pot. On this edge a U or V shaped notch about 2 inches deep and 1 inch wide is made. At the time of potting the seedling a root piece of about 3 inches in length close to the collar of the plant was made to project out through the above notch. After a month when the seedling had established itself, the scion shoot was inarched in the usual manner to the projecting root piece below the collar. The success of the method was high on the basis of the number of plants on which the operation had actually been made. But if the seedlings in the bed are considered, the success was only about 23 per cent, as several seedlings died while repotting them to expose 3 inches of sub-collar region. So the method has to be further perfected before adoption as a nursery practice. (Plate 50.)

Top working.—The usual method of top working is by pruning the tree of its main limbs and inarching to the new shoots that arise scions which have been previously grafted on seedlings in pots. In the West Coast a method of insertion under the bark of scion wood eight inches long pre-cured as for side-grafting is in common use and has given very high success in trials at Taliparamba.

Comparison of grafting methods.—A study of root grafting, inarching and double-working in relation to orchard performance of the tree has shown that the inarched plants and root grafts of *Bangalora* and *Neelum* were best in height, but in respect of tree spread and scion-stem circumference no significant differences were evident between any of the treatments. Analysis of fruit yields in number showed that *Neelum* is significantly superior to *Bangalora* while on the basis of fruit weight, *Bangalora* inarched and root grafts were the best.

Seedlings and grafts planted in different months, from May to October and subjected to 'Malling' method of layering failed to produce roots at bases of the fresh shoots even after two years. Planting of mango cuttings did not succeed at the station.

An occasional rooting was observed by using cinctured cuttings but it did not offer any hopes of getting a fair percentage of success.

Treatment with Hortomone, A.—A proprietary product of the Imperial Chemical Industries and B-indolyl acetic acid tried as hormones, merely showed evidence of formation of root initials in a few cases. No successful method of obtaining clonal root-stocks in mango has so far been got.

Culture and inter-cropping.—From experience on the Fruit Research Station, Kodur, it is suggested that inter-cropping with vegetables or leguminous crops in the early stages may be made, as this will not only bring extra remuneration but also keep down weeds. When the tree has attained bearing age, it is suggested that one or two ploughings or hand diggings may be given. Occasional green manuring can also be done.

It is a general practice, especially in Circars to give a deep ploughing to mango gardens in October–November or early December, as this is supposed to arrest the growth and induce formation of flower buds. Some growers remove the soil round the trunks exposing the roots to a depth of 12 inches for two or three weeks early in December with the same objective. Trials conducted at Kodur in 1944 on this practice showed no difference between the treated and untreated trees of the same age and variety. This might be due to different circumstances in different regions. But root pruning is, however, not advisable until its use is definitely indicated by further trials.

Pruning.—No pruning is done to the mango in our country. But considering that it is a terminal bearer and that other kinds of fruit trees, especially deciduous ones with the same habit, benefit by tipping the shoots, i.e., removal of the terminal portion of the leader shoots, this treatment was given for 25 selected shoots in a small trial at Kodur. But the results showed that 36 per cent of the shoots died of the treatment and over 60 per cent of the shoots produced four growth flushes on the year after the treatment in the year. So this treatment is not satisfactory because of the high mortality of shoots and increased vegetative growth. It may also be pointed out that since mango bears its fruits predominantly on leader shoots the treatment will not be of immediate benefit.

A similar trial was conducted on mango limbs of approximately two inches in diameter in three periods January, June and November. One batch was pruned at the tip to an approximate length of 24 inches and another batch was pruned to the middle. It was observed that in January-pruning there was no difference between the two treatments. In June and November-prunings, centre pruning induced earlier and more abundant vegetative flush than tip-pruning and in June-pruning the tree had a more prolonged growing period. With regard to blossom bud formation, in both the current season as well as in subsequent seasons, centre-pruning in June was better. As, however, heavy yields are

associated with dense foliage, pruning does not seem to be called for except to correct the form and stature of the tree in varieties which tend to branch low and irregularly.

'Ringing' and 'girdling' which also constitute a form of pruning have been the subject of a few trials at Kodur. It has been reported that ringing mango shoots in August by removing ½ inch of bark has effectively increased the bearing of mango at Sabour in Bihar.

Experiments at Kodur on different methods of ringing showed that it is not possible to commend the practice.

Cropping and harvest.—Some grafts and budded plants commence to bear a few fruits even in the second year while usually they commence to bear about the fifth year. Seedlings commence bearing a little later, about the sixth year. Polyembryonic seedlings are observed to be as early as grafts or budded plants. A normal crop can however be expected about the twelfth year in grafts while seedlings may yield similar crops about the fifteenth year.

The season of flowering in the West Coast is usually in December about a month in advance of other regions. At Kodur it was observed that flowering commenced any time between November and January depending upon the season. In years when the north-east monsoon is rather prolonged, flowering tends to be delayed.

The season of harvest in the West Coast commences in February–March and peak harvests are obtained in April–May; it is April to July in the Circars and May to August in the rest of the State.

The peculiar conditions of climate and the existence of certain varieties adopted to the climate in South India are responsible for the unique feature of off-season production. These varieties, especially *Neelum* are capable of producing several waves of blossoms. In certain Tamil districts off-season bearing occurs from September to January.

One of the important problems in mango production is the low yield of choice fruiting varieties. During the investigation of the problem it was observed that the cause was a low percentage of perfect flowers. Double-working them with intermediate stem piece of a prolific variety, as has been mentioned already, only increased the blossoms with no appreciable increase in crop size. The matter needs further study.

An important problem in mango production causing much concern to the producers is the frequent occurrence of lean years. It has been suggested by several workers in the north that mango is subject to alternate bearing or to the phenomenon of periodicity of bearing. Several studies had been undertaken at Kodur to investigate this problem and the conclusions may be summarized as below.

At Kodur the growth in important commercial varieties of *Neelum*, *Bangalora* and *Baneshan* is characterised by two distinct active phases, one occurring from February to June and the other in October–November. Minor flushes had been also observed mainly in December. The flushes occur in February, June and November at Taliparamba. The amount of extension growth, the duration of growth phase and the time of cessation of growth vary with varieties and also in the same variety from season to season. No cyclic growth tendency was noted from year to year but the growth depended on the previous performance of the shoots. Shoots that had flowered in the previous season or more especially those that carried fruits to maturity, usually put forth much less extension and fewer laterals than those that had not. Flowers were borne largely on shoots which had emerged in the February flush of the previous year and could complete their growth in June provided that the north-east monsoon was not unusually wet. Leaders that had carried fruits to maturity in the previous year were not likely to bear flowers in the following seasons. because of their low extension growth. It was also observed that while leader shoots were important for their large proportion that flower, the laterals were important owing to their larger numbers. It was also observed that some varieties like *Neelum* and *Chinnasuvarnarekha* produced flowers and fruits on laterals of the October–November flush, in the season immediately following.

In regard to the length of shoots, it was found that those of medium length were the most productive in the following season.

With the aid of the above observations, it is possible to give some suggestions to increase productivity and regular bearing in our orchards.

Our orchards should be planted to varieties which are known to be regular and prolific yielders. Grafts from trees whose performance has been recorded to be satisfactory over a period of at least four years should be employed. Such cultural and irrigational practices as would promote a vigorous growth in the first flush but help cessation of growth before June and again in October-November should be adopted in orchards.

The use of hormones to prevent fruit-shed was tried on a small scale. 'P.P.L.' Tomato set, a proprietary product, was tried by spraying the panicles in three shy bearing mango varieties, but the beneficial influence was felt only on fruit-set and not on the final stand on the tree.

The yields of mango depend on the tree variety and seasonal factors. To go by the number of fruits per tree will be misguiding because smaller fruits are borne in more abundant numbers; for instance, tree No. 23/5 of *Pacharisi* yielded in the season 1945–46, 3,355 fruits which weighed only 487 lb. while tree No. 8/3, supplied as *Mulgoa* (Chittoor), yielded only 1,640

fruits which weighed as high as 659 lb. It was remarkable that all the 26 trees listed as best yielders of the year were of medium or poor quality.

Mango products.—The usual product from mango prepared in this country is the dehydrated pulp which is called '*Tandra*' in the vernacular. The colour and consistency of this product varies with the conditions under which it has been prepared and the success with which dirt has been kept off while sun-drying the product.

Since the opening of the Fruit Products Laboratory other methods of preservation of the fruit have been perfected. Of the important commercial varieties of mangoes, *Neelum*, *Baneshan* and *Mulgoa* preserved well in syrup of 40–45° Brix in plain or lacquered cans exhausted for 10 minutes at 185–190° F. The canned products keep well for more than one and a half years in storage. There is thus scope for the commercial canning of mangoes in the State. Hydrogen swell formation in canned mangoes, however, has to be studied more critically.

Mango jam.—All important commercial varieties of mangoes including the *Bangalora* are suitable for making jam. The fruit to sugar ratio is 1 :3 and the addition of 0·5 per cent tartaric acid is desirable.

Mango chutney of the sweet type has been prepared and found to be a good product.

Present mango research and the future.—At the Fruit Research Station, Kodur, variety testing and collection of polyembryonic and off-season bearing mangoes has been undertaken. The several propagational methods have been thoroughly tried and the technique improved. Double working, using prolific intermediate stem pieces, has been under observation to induce prolificity in shy bearing varieties. The use of polyembryonic rootstocks to induce uniformity and vigour has been established. The several varieties in the State have all been described and their correct varietal position determined so that the confusion of names has been minimized to some extent. Controlled pollination studies have produced crosses of outstanding merit which are in great demand from growers.

At Taliparamba, varietal studies have enabled the selection of early, midseason, and late varieties of mango suited to the tract, viz., *Olour*, *Bennet Alphanso*, *Alphanso*, *Peter*, *Chendrakaran*, *Kalepad*, *Neelum* and *Mundappa*. Several trials were made with inarching to make the method cheaper. The use of hill grass to hold plants instead of pots was considerably more economical. Side grafting was not ideally suited to the west coast. A method of top working by insertion or slotted side grafting has been perfected.

The mango is a perennial crop which takes eight to ten years for economic bearing and the systematic research on the fruit

commenced only about a decade and a half ago. The above is a record of work done and the results achieved during the short period. But much remains to be done to bring the fruit to a position which it rightly deserves not only because of its vast area but also due to the existence of many choice varieties.

Uniformity is of prime importance for mangoes and efforts should be taken towards this end. The nurseries which have a great part to play in this matter should be brought under control and made to adopt improved practices. They should adopt the nomenclature evolved at the Fruit Research Station, Kodur, and describe the variety before giving a name to it. They should maintain performance records of parent trees from which scion wood is obtained, so that these are available for perusal. The employment of polyembryonic mango seedling as root stock should also be encouraged.

More off-season bearing varieties of trees should be collected and their behaviour studied under varied conditions of climate and soil and also the inheritance of this character by the clones.

Hybridisation blending economic characters especially those noted in single trees as against the varietal characters, should be undertaken for the creation of better strains.

It will be profitable to study the performance of the 39 other species of Mangifera as rootsocks for the superior varieties. Collection of these species may be made for this purpose.

The studies of blossom biology so far made have thrown fresh light on the problem of irregular bearing. Work on cultural and other practices meant to promote regular bearing is likely to result in a great benefit to the growers.

CITRUS FRUITS.

Citrus fruits have been known in India for so long a time that it is held to be the home of some species. The lime and certain types of lemons were thus known but the tight jacket oranges are of comparatively recent introduction. There has been a growing realization on the part of the consumers as well as growers of the importance of citrus fruits and during the last few decades the area under oranges, especially in this State has considerably increased. The preparation of squashes from these fruits is a flourishing industry even in India and is likely to enjoy more popularity in the future.

Production.—It is reported that the area under citrus fruits in 1947–48 in this State was about 46,000 acres comprising roughly 15,000 acres under sweet oranges, 16,600 acres under *Vadlapudi* oranges and 14,000 acres under other citrus types. The total annual production has been estimated as 21,000 tons of sweet oranges, 39,500 of limes, 10,400 of loose jackets, 15,300 of *Vadlapudi* oranges and 8,500 of other types. Madras is rated as the leading citrus producing State in India with 25 per cent of the

total area in India and Pakistan put together. The State used to export annually to other parts of India under 1,300 tons of sweet oranges and about 4,200 tons of limes. Nevertheless it also imported 6,500 tons of loose jacket oranges from Mysore, Coorg and Madhya Pradesh.

Crimate and soil.—The citrus group includes several fruits which have different climatic and soil requirements. Sweet oranges have been found to be thriving successfully in the arid plains of the State such as are met with in Ceded districts. The loose jackets, on the other hand, have been successful in humid tracts with slightly higher elevations such as the agency tracts of Visakhapatnam and Godavari districts, Lower Palnis, foot of the Nilgiris, Yercaud Hill, Wynaad and Coorg. Limes are found throughout the plains, the frostless arid and hot climate having suited them best. Lemons seem to be very adaptable in their climatic requirements having been successfully grown both in the plains as well as in humid atmospheres.

The effect of atmosphere on the sweet orange is reflected in the taste and appearance of fruit. In the more humid regions of Wynaad, Lower Palnis and Coorg, the fruits are insipid though juicy. Similarly, the fruits of *Sathgudi* at Kodur obtained in the main fruiting season in October to February are sweeter than those harvested in the off-season in August. It was also found on analysis that the brix-acid ratio gradually increased from August to the end of the season in February.

The influence of the season on the taste of fruit is also demonstrated by the *Vadlapudi* orange of the Circars. It is not palatable owing to extreme acidity during most part of the year, but in summer, when low humidity and high temperature conditions prevail, it develops sweetness.

Loose jacket oranges or mandarins have not been successful in the arid plains where they have failed to yield profitable crops.

The preferences of citrus fruits to certain soils has been brought out very clearly through great failures in some regions. The decline within a few years of planting of trees on the shallow rocky soils of Yercaud, the high mortality at a comparatively early age of *Vadlapudi* oranges on the stiff soils with high water table in Guntur, and Krishna and the early decline of young orchards in the Kurnool district on soils with high water table are instances.

In surveys of orchards conducted, sweet oranges were found not successful in areas where rainfall exceeded 100 inches, while lemons were found to thrive in all parts of the province from sea level up to 6,000 feet above. Acid lime proved more adaptable than sweet oranges, but showed relative intolerance to heavy rainfall conditions when compared to lemon.

One of the commonest defects associated with selection of sites was the situation of orchards where the water table was more than six feet high from the surface. A good number of diseases and

pests were also found to cause heavy recurring damage to orchard trees and crops.

Varietal introductions and trials.—There is much confusion of names in the citrus group. Most of the workers had not given detailed attention to the several Indian types. As a preliminary step to clarify the position, and also to indicate the suitability of the several types to local conditions, a large collection of plants from several regions with their regional names has been made at Kodur. This study is especially useful in clearing up confusion arising out of varied regional names being given to the same variety or species.

Sweet orange (citrus sinensis).—The most popular variety of sweet orange in the State is the *Sathgudi* which is grown mostly in the districts of Cuddapah, Chittoor and Kurnool but is fast spreading to other parts, especially in Madurai and Tirunelveli and the Circars. The variety is said to have first gained prominence in the village of Sathgur in North Arcot district from where it spread to Karvetinagar and Nagari in Chittoor and later to Rajampet taluk in Cuddapah district where it has attained commercial importance. It is often known as *Chinee* (*Cheeni*) and *Nagari* orange.

The next important commercial variety is the Batavian orange which was extensively grown in the Circars. It gets its name from the supposed introduction from Batavia to Palacole in West Godavari district which was one of the early Dutch settlements. The fruits mature in rainy season and further the fruits get an early colouration due to the practice of basketing them against the fruit sucking moth. On account of these two causes the fruit quality is inferior to *Sathgudi*.

In parts of Kurnool district, a small area was occupied by *Mosambi*, also called *Mussambi* or *Muzambique* orange, characterised by prominent streaks on the rind and a circular groove at the stigmatic end.

It is learnt that *Washington Navel* has been introduced from Australia into some private gardens where it is reported to have failed to bear regularly and the fruits also were coarse, thick skinned and flavourless. Of the *Navel* oranges tried at Kodur the *Buckeye Navel* has been producing high yields of fruits of good quality. The *Blood Red* orange on the station also failed to develop the characteristic colour of flesh. The *Valencia Late*, a normal smooth skinned sweet orange, yielded fruits of good quality, though, contrary to its reputation for late maturity, it did not keep fruits till after the normal harvest season. Delayed harvests are reported to have produced at Penagalur pithy and insipid fruits.

From the present experience and study it is possible to recommend only Sathgudi for further extension in Madras.

Mandarin (C. reticulata).—The varietal position of mandarins or loose skinned oranges grown in South India is still not clear. While Tanaka thinks that all the South Indian types belong to the

Santhra group and are the same as the *Chinese Ponkan*, Webber does not accept this. " There is no doubt, however, that the *Kukal* orange of some parts of Nilgiris is a distinct variety from the oranges grown at Kallar and Wynaad " (Naik, 1948). The Nagpur Santhras are grown in such entirely different conditions of soil and climate from those of the South Indian types that it is possibly a different variety. It is also reported that there are differences in glucosidal contents of the several types of mandarins grown in India. The glucosidal content, work on which has been done at the Andhra University may help to classify the oranges.

The mandarins are commercially being known after the region in which they are grown as Wynaad, Coorg, etc., except Kamala, which comes from the Agency tracts of Circars.

Lime (*C. aurantifolia*).—The usual lime grown all over the State is called the *Kagzi* lime. But it was observed in a survey that several bud strains are found in private orchards. One with a translucent skin with a slight mamilla and another without the mamilla were noted. Another ' hybrid ' having red-fleshed pulp was noted at Madanapalle. But none of them have yet been compared with the *Kagzi*.

Tahiti, a variety with nippled fruits having fewer seeds but less prolific than the *Kagzi*, has been tried at Kodur. It is also claimed to be resistant to the wither tip disease.

The sweet limes occasionally met with in private gardens and also at the Fruit Research Station, Kodur, are supposed to be hybrids. The so-called sweet lemons of Madurai, Malabar, Salem and Nilgiris, are also supposed to be hybrids.

Lemon (*C. Limon*).—Lemons are a new introduction into South India and have not yet made their mark in spite of the several virtues they possess, viz., they are adaptable to any region in the State; they bear practically throughout the year; they yield heavily fruits which are three times the size of lime, giving juice of the same acidity and taste as that of lime.

Of the several varieties tried at Kodur, the following are recommended :—Seedless, *Nepali Round*, *Italian*, *Napali Oblong*, *Lisbon*, *Eureka*, *Villafranca* and *Malta*. The last named variety has been found to bear even from the second year of planting.

Two forms of lemon, which are locally known as *Addanimma*, have been met with in some local orchards. At Kodur one tree of this variety yielded 1,248 fruits in the ninth year.

A lemon whose leaves resemble those of acid lime, was located in a private orchard at Rajahmundry and has been designated as *Rajahmundry lemon*. It has yielded 603 fruits in the fifth year.

Pummelo (*C. grandis*).—There are no specified varieties except those which may be differentiated as red and white fleshed.

Grapefruit (*C. paradisi*).—Grapefruit is a novelty in South India and the bitterish taste may not be liked by the generality of

consumers. Several varieties have been tried at the Fruit Research Stations, Kodur and Kallar, as also in some private orchards. At Kodur a seeded variety '*Poona*', and a seedless variety called '*special*' have given encouraging performance. At Kallar the varieties '*Marsh*' and '*Triumph*' have produced moderate yields. But it is reported that in a private orchard at Penagalur in Cuddapah district, *Triumph* failed completely, while *Marsh* yielded up to 1,500 fruits per year.

Citron (*C. Medica*).—Of the varieties of citron, the medicinal fruit, *Mahalung* and *Bengal Citron* have been promising. There is also a variety with large fruits weighing up to 8 lb. 11 oz. which is called Hawaiian " pummelo ".

Kumquat (*Fortunella sp.*).—No varietal comparision has been done on this fruit tree which is more popular as an oranamentation.

Sour Orange (*C. aurantium*).—There are no varieties of sour orange which owing to their bitter taste are of no commercial importance. Some of them are however of value as rootstock owing to their resistance to some root and stem rot diseases.

No fresh light has been thrown on the taxonomy of any of the foregoing kinds of fruit by the observations made at the station and therefore the classification and nomenclature advocated by Swingle has been in use even though it does not help to clarify the status of at least one of our commercial varieties, the *Vadlapudi* orange and also of *Gajanimma*, *Dabba*, *Kichili* and *Billikichili* and the like. Having missed mention in his great tratise on the subject, they are designated as hybrids as this is supposed to be simpler than adding to the confusion by adopting the specific names.

Vadlapudi has gained a great prominence in Circars due to its sweetish pulp with acidic twang, its refreshing juice especially in summer and its medicinal properties. It has been extending fairly quickly though, unfortunately, on uncongenial soils.

Evolution of strains—By selection.—Several species of citrus, except the pummelo, exhibit polyembryony and, often, the apogamic seedlings smother the sexual seedlings which thus get eliminated in nature. This is the rason why there has not been appreciable deterioration in the quality of the *Sathgudi* or the loose jacket oranges which are grown on the hills, in spite of years of seed propagation. Nevertheless clonal propagation will further minimise the chances of variation and also enable the utilization of rootstock effect, which is no less important than hybridization, in the improvement of the fruit quality and size. Budded limes, whatever the rootstock, have yielded more than the seedlings in a trial at Kodur. Ever since the simple methods of vegetative propagation have been demonstrated at the Fruit Research Station, Kodur the demand for budded plants has increased and over fifty nurseries have sprung up which adopt the methods of budding perfected at the station.

One of the advantages of vegetative propagation is the perpetuation of superior bud variations whenever they occur. In Citrus, bud sports or bud mutations commonly occur. Not all of them are desirable. It is as important to avoid inferior mutations as to perpetuate superior ones. Too often the inferior sports attract the attention of the ignorant by their more robust appearance. It is therefore of utmost importance to select bud wood from shoots whose performance has been observed at least for one season. Superior mutations have also to be spotted by careful observation.

A pink fleshed *Vadlapudi* bud sport was spotted at Tenali by an extension worker and is now perpetuated as a bud strain. Search for desirable bud sports has been in progress and a few progenies are under examination.

It has already been mentioned that a few limes with translucent skin have also been noted.

No hybridization has yet been attempted in citrus fruits at our Fruit Stations.

By other methods—(a) Rootstocks.—As has already been pointed out the determination of the right kind of rootstock is as important in vegetatively propagated plants as selection or hybridization in seed propagated plants for the improvement of a crop. Several kinds of rootstocks had been under trial for *Sathgudi* and acid lime during which several interesting facts came to light, all of which cannot be enumerated here for want of space. The salient results may be summarised as follows :—

(1) *Sathgudi* trees budded on acid lime, *Gajanimma* and rough lemon are most vigorous in growth, having produced the largest tree size in about nine years, while those on wood apple and loose skinned orange were the poorest in size.

(2) Smooth bud union, which is a sign of compatibility, was found to a maximum in *Sathgudi* trees budded on *Sathgudi*, while disparity was greatest on wood apple and *Kichili*, with the trees on sour orange and pummelo being intermediate.

(3) *Sathgudi* trees on wood apple and *Gajanimma* yielded the earliest crop while the seedling trees are yet to reach the bearing stage.

(4) Trees on *Gajanimma* are the most susceptible to gummosis and root rot diseases, especially in years of heavy rainfall.

(5) With acid lime scion no appreciable differences in tree growth has occurred between rootstocks, though trees on rough lemon show the largest stem size, and the budded trees have clearly recorded larger tree size than the seedlings.

(6) Smooth bud unions are associated with acid lime on acid lime, while the former on *Gajanimma* was unsuitable.

(7) The budded acid lime trees have been clearly earlier than the seedlings by about a year.

(8) Acid lime trees on *Gajanimma*, acid lime and rough lemon were good in the order given, in respect of heavy yielding capacities, while seedlings were the worst.

(9) Acid lime seedlings and budded trees on the same rootstock were less affected by die-back and wither-tip diseases,

while the trees on *Gajanimma* showed the largest amount of dead wood on account of these diseases.

It was found at Kodur that till the eighth year of planting, the acid lime budded trees on *Gajanimma* yielded 24,260 fruits weighing 1,880 lb. per tree while the lime seedlings yielded in the same period only 13,890 fruits weighing 1,220 lb. per tree. These differences are so large that the acid lime growers should go in for budded plantations in preference to those of seedlings, and particularly to plantations on *Gajanimma* rootstocks.

It is unfortunately not possible to present similar results from *Sathgudi* orange rootstock trials, since these trials were vitiated by root-rot incidence to such an extent as to make the results unreliable.

Sathgudi has been budded on rootstocks of other genera. In all cases the union has resulted in extreme incompatibility producing early death on *Aegle marmelos* and early decline and stunted growth on *Atalantia monophylla*. *Feronia elephantum* (wood apple) has produced extremely dwarf trees with incompatible bud joints. It was however found to be very early and produced fruits of excellent quality, but the combination is not profitable for commercial planting.

It is, therefore, advisable to utilize rough lemon as a rootstock for Sathgudi until another type is proved to be of merit at some later date. Sweet orange may be of value for the good quality fruits it produces from the commencement of bearing while acid lime may be of special merit in water logged conditions.

It is reported that lemon layers do better than budded plants on rough lemon.

Agronomic Trials and Experiments—Nursery practices.—Since most citrus species of possible rootstock value exhibit polyembryony, it has not been found necessary to attempt clonal propagation of rootstock for uniformity.

A trial was conducted in which the performance of *Sathgudi* budded on seedlings of different thickness proved that the thickness of the seedlings had no effect on the resulting budlings. In another trial in which *Sathgudi* was budded on seedlings of different kinds —those that germinated early or late or those that germinated in groups of more than one (apogamic seedlings), there was no significant difference between the treatments.

The method suggested for raising the rootstocks adopted at the Fruit Research Station is as follows :—

The seeds, after extraction in such a manner as not to injure them, are washed free of pulp, dried in shade slightly and sown soon after on raised beds six inches high, with a spacing of one inch in the row and three inches between the rows. The seeds may be preserved, if necessary, for some time in tightly closed tins in powdered charcoal. The seeds germinate in about 20 days. Six to nine months later the seedlings are lifted with naked roots and transplanted into beds with a spacing of 9 to 12 inches in the row and 18 to 24 inches between the rows. At this stage weak, unhealthy and undersized seedlings are rogued out which incidentally

Plate 71.—Citrus Nursery.—Seed-bed Section.
Fruit Research Station, Kodur.

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eliminates any sexual seedlings that may survive. The seedlings are irrigated immediately after planting.

A nursery transplanter has been devised at the Fruit Research Station which not only reduces the damge at the time of transplanting the seedlings but also results in great economy since one individual can plant with its aid, an increased number in a given time.

No further selection of vigorous seedings is felt necessary in the second nursery except to eliminate the very slow growing ones which do not attain buddable size even after 24 months.

The method of budding adopted for citrus plants is the shield method [either T or inverted T (⊥) method]. Trials to work out the correct budding technique conducted gave the following results :—

(1) Presence of a very thin slice of wood in *Sathgudi* orange and acid lime bud shield has produced a significantly higher ' take ' than absence of wood.

(2) Primary lopping of citrus rootstocks lowered the bud ' take ' in some cases.

(3) Primary lopping of citrus rootstocks at the time of bud insertion stimulated an earlier bud break both in *Sathgudi* orange and acid lime.

(4) Delayed primary lopping of citrus rootstocks after the *Sathgudi* bud had produced not less than two inches of extension growth resulted in a comparatively rapid extension growth of bud sprouts.

(5) Presence or absence of wood in *Sathgudi* orange and acid lime bud shields did not affect the period taken for bud break or rapid extension grown of *Sathgudi* and acid lime bud sprouts.

In the fruit nursery attached to the Fruit Research Station, budded plants of known merit are being distributed. The demand for the plants has been very great, orders being registered in advance by two to three years, thus indicating the need for starting more nurseries.

Irrigation.—The mandarins which are grown in the humid parts of this State are not irrigated. But all other kinds which are in arid regions require irrigations at frequent intervals. The common method of irrigating young trees is by the provision of round basins about six inches deep, the diameter varying with the age of the tree. Root studies at Kodur have indicated that only 30 per cent of the fibrous roots are found within the drip of the leaves. It was observed that *Sathgudi* orange on *Gajanimma* rootstock about 21¼ months after bud insertion had a maximum root spread of about 18 feet. This clearly shows that the practice of applying irrigation water to a basin within the drip of the leaves is inadequate. It has been recommended that the basins should be at least two to five feet beyond the drip of the leaves. It is also suggested that the basins should be six inches deep at the periphery and gradually rise up towards the tree so that the trunk does not come in contact with water. The provision of an inner ring round the

trunk is found to cause accumulation of water round the tree in rainy weather which is deleterious. The basins have to be widened as and when plants attain larger size.

For grown up trees, the extended basin or check method of irrigation is recommended. Bunds are formed between the rows of trees at right angles to each other. The only possible difficulty in this system might be that bullock power cannot be cheaply used for hoeing. But this can be overcome either by use of hand worked labour-saving implements like the Planet Junior Hand Hoe or by forming the bunds after each culture with the aid of bund formers.

Definite recommendations regarding the time and quantity of irrigation cannot be made for all orchards. But excess of water should be avoided in citrus orchards. A rough test to find out the need for irrigation is to examine the soil at a depth of 12 inches by digging crow-bar holes in half-a-dozen spots selected at random in the orchand and if the soil at this depth crumbles easily in hand, water may be applied.

Soil culture.—Root studies conducted on *Sathgudi* trees have shown that the majority of the feeding roots are in the first foot of the soil. Therefore deep culture can easily be seen to injure the feeding roots and impair nutrition.

It has been reported by an orchardist that ploughing in summer has adversely affected the crop. This is only in conformity with the findings at the Fruit Resarch Station. Opening up the soils in summer also increases the loss of organic matter besides adversely affecting soil texture. The removal of weeds is, however, specially important in summer.

Ploughing during rains also adversely affects the texture of the soil and should be avoided. Growing of intercrops and green manure crops can be attempted in this season as they incidentally assist in the control of weed growth.

Considering the above points a system of culture has been evolved at Kodur. The main ploughings or digging should be done in December when the trees are in comparatively inactive stage. Weed growth should be occasionally smothered as and when necessary by using light implements like the Junior Hoe, the culture being not more than two inches deep. Sowing and incorporating of green manure crops should be done in the rainy season, the ploughing for both purposes being shallow.

Pruning.—No experiments have been done in Madras regarding the best form to which citrus trees may be trained. Being an ever green, it requires a minimum of pruning. If any form is adopted it should more or less conform to the shape that is natural to the kind. It should also involve little or no heading back of limbs. This can be achieved by repressing the prospective branches in their very emergence by pinching or thinning. Attention may be paid to the formation of a strong frame work by allowing four

of five well-placed scagold limbs. Removal of stock-sprouts and water-suckers is an important item of work in the early stages. Root pruning is not a commendable practice as it tends to shorten the life of plants.

Manuring.—No elaborate trials have been conducted on citrus for the reason that trials conducted in one region will not be of any value elsewhere.

The ryots of Rajampet taluk have been applying 12 lb. of groundnut cake, 9 lb. of fish manure, 3 lb. of bonemeal and 60 lb. to 75 lb. of farm yard manure to full-grown orange trees.

Several mixtures consisting of farm yard manure or compost, oil-cakes, ammonium sulphate, potassium sulphate and super phosphate in varying proportions have been used in gradually increasing quantities with advancing age.

The most common deficiency disease found on citrus is the one due to the deficiency of zinc, which is manifested in the yellowing of the lamina of the leaf while the ribs remain green. Spraying with a mixture of lime and zinc sulphate solution has been reported to provide temporary relief.

Application of zinc sulphate in crowbar holes against 'frenching' in orange gardens was tried in some centres. It would appear that application of zinc sulphate through crowbar holes is effective if at the same time the trees receive careful attention in the form of culture, manuring and irrigation.

But zinc deficiency is often caused not by its absence in soils but by its non-availability in alkaline or excessively calcereous soils. In such cases, application of more zinc to the soil may not be of any material value.

It is recommended that December or early January is the best time to apply manure to citrus after harvesting the previous crop and before the commencement of the flowering for the main crop. In lighter soils where two applications are favoured the second application may be made between June and August. In the heavy rainfall tracts on the hills, it is better to manure in July-August rather than in December when there might not be enough moisture in the soil.

As it has already been seen that the feeding roots extend far beyond the drip of the leaves, it is clear that the practice of applying manures in a ring round the trunk cannot satisfy the needs of the trees. It is necessary that the whole area in the orchard be uniformly manured.

Cropping, harvesting and yields.—The flowering of the main crop of *Sathgudi* occurs from December to April and the harvests last from the following November to March. This main season is locally called the *Angam*. For the off-season crop, called the *Gairangam*, flowering occurs from September to the beginning of December and the fruits are harvested from the following June to November. The Batavian oranges in the circars are in season

from July to December. The *Vadlapudi* orange is in season from August to January for the main crop and from February to May for the off-season or second crop. To prevent the attack of the fruit moth, basketing of fruits with cheap palmyra leaf baskets is common in the Circars, as a result of which the fruits become prematurely and irregularly pale yellow in colour. The *Sathgudi* which is not basketed develops the best golden yellow or orange colour only in the main harvest in December to February. The third crop of *Sathgudis* which is harvested between March to June is from an occasional bloom that appears in June-September.

The proportion of yields in the three seasons varies with weather conditions at the time of or just preceding each blooming. Records show that the off-season crop accounts for one-fifth to about one-third of the gross harvest in a year. The occasional failure of the main season crop may increase the off-season crop. Studies of the progeny from trees yielding a heavy crop in the main or off-season have shown that the character is not inherited by the clones.

The loose-jacket oranges of South India also yield two crops a year fairly regularly. In Wynaad the seasons are from July to September and December to January. The Kamalas of Circars are in season from October to January, while at Kallar the main harvest season is from August to October and the off-season harvest from February to March. On the Shevroys there is only one season from October to December while on the Lower Palnis there are two seasons, August-September and December-January.

Limes are in harvest throughout the year. The peak periods of harvest are however limited to March-April in the Circars, July to September in Rayalaseema, June to August in Madurai and North Arcot, April to June in Guntur and Nellore and January to March in Tirunelveli. At Kodur it has been found that about 80 per cent of the year's crop is harvested from May to August, 14 per cent from January to April and 6 per cent from September to December.

Pummeloes, grapefruits and citrons are in season generally from August to December. The lemons yield 70 per cent from May to September. Kumquats can be harvested all through the year, with maximum harvests from July to December.

The mean yield of the *Sathgudi* in private orchards is reported to be roughly 600 fruits per tree. In good orchards 1,000 fruits per tree per year is considered normal and 1,500 to 2,000 fruits as very good. According to an estimate in the Report on the Marketing of citrus fruits in India, the acreage yields in South India are put at 90 to 120 maunds for Batavian oranges, 90 to 100 maunds for *Sathgudi* oranges, 200 maunds for *Vadlapudis*, 150 maunds for loose-jacket oranges, 225 to 300 maunds for acid limes and 180 to 400 maunds for pummeloes.

Products.—At the Fruit Products Research Laboratory, Kodur, canning of loose-jacket oranges was as successful as the commercial product of the grapefruit. Lime, lemon, *chinee* and loose jacket orange squashes standardized in the Research Laboratory are

popular. Lime juice has been utilised instead of citric acid to raise the acidity of orange juice. Lime juice cordial is an excellent product. Pummelo, citron, kumquat, etc., have been utilised for the preparation of attractive squashes. Blended products like orange, tomato, orange-tomato-pineapple, carrot-orange, etc., have been prepared. The sweet *Chinee* orange, the *Kitchili* fruit and kumquat can be used for preparing orange marmalade of high quality. Marmalade prepared from marmalade orange was very bitter in taste. Kumquat has been successfully candied to produce an attractive product.

Dietetic value.—The citrus fruits are a fairly good source of vitamin C. Among the species of citrus, lime has been shown to contain more vitamin C than the rest having about 63 milligrams per 100 gm. The grapefruit is a good source of vitamin B1 also, having 40 international units per 100 gm. Being very easily digestible and the juice being easily expressible they are prescribed as a diet to sick people.

Work of the research station and the future—Kodur.—The important results of work done at the Fruit Research Station, Kodur, are as follows :—

The several rootstock trials indicate that *Jamberi* may be used as a rootstock for *Sathgudi*. The method of shield budding by keeping a small slice of wood attached to the bud is the best method of budding citrus. The best season for budding is from July to September.

Citrus fruits are very important on account of their diatetic value. The phenomenal increase in the area under these fruits during the past two decades is an indication of the great future. In the case of mandarins, Madras has the disadvantage that the peak seasons of harvest do not fall in summer when these fruits are most relished and in consequence large quantities of Santhras were being imported into the State. Selection of off-season bearing trees and their progenies may, therefore, prove fruitful. The squashes of citrus fruits are already popular all the world over and the large number of different kinds of citrus fruit in our country offer possibilities of blending their juices to prepare squashes and marmalades and to standardise them. The standardisation of rootstocks and popularisation of improved methods of vegetative propagation, will also greatly help the progress of citrus growing in this State.

BANANA.

The banana is said to have been originally cultivated for its edible root. But now every part of it is made use of by man. The ripe fruits are used as dessert and for religious offerings, while the unripe fruits of some varieties are the most common vegetable in South India. The 'hearts' and 'core' of the pseudo-stem are also much relished as vegetables. The leaves are the commonest dinner plates in South India. The leaf sheath is a very useful packing material in floral trade. The fibre is used extensively for

packing and in cordage and textile industries. The banana flour is a good invalid food. Figs, jams, chips and a number of other products are prepared from the banana. A story is told of a lady who proudly served her guests a dinner with a menu of dishes all from banana including the 'rice' which she prepared from the flour. The dinner was, of course, eaten out of banana leaves.

The banana yields heavily producing over ten tons per acre and brings a good remuneration to the grower. As a cash crop it has been popular in the wet land areas for a long time, being in fact, the only major fruit grown in the wet lands. It is one of the fruits with a high calorific value. It is, therefore, easy to see that banana can help to mitigate the food shortage in the country as a subsidiary food. Its cultivation especially on the hills is to be encouraged. In hilly regions the soils are unsuitable for most other crops and bananas can be raised at cheap cost and without irrigation.

Production and importance (*Plate* 52).—The prewar average area occupied by banana in this State was 136,455 acres and together with 47,504 acres in Travancore, 21,030 acres in Mysore and 2,500 acres in Cochin and an undetermined area in Coorg, it forms 53 per cent of the total area under this fruit in the country. To some extent the acreage varied from year to year having been 154,000 acres in 1934–35 and only 136,000 acres in 1939–41 and about 130,000 acres in 1942–43 and 168,650 acres in 1947–48. From the figures of 1947–48 it is seen that Malabar leads with about a third of the area in the State followed by Madurai, Tanjore and Tiruchirappalli districts with about 19,000, 12,900 and 17,000 acres respectively. Other districts in the order of the extent grown are Tirunelveli, Coimbatore, Salem, East and West Godavari, Visakhapatnam and South Kanara. The rest had less than 2,000 acres under the fruit. Taking the varieties into consideration it is noted that *Poovan* accounted for an annual production of about 741,000 tons from an area of 74,000 acres in 1941. *Nendran* and *Monthan* were next in importance accounting for about 90,000 tons each per annum from 14,900 acres and 11,300 acres respectively. Hill bananas occupied about 6,500 acres and produced about 16,000 tons per annum. The total production in 1941 was about 1,133,000 tons of which roughly 910,000 tons were ordinarily exported by rail from producing centres to outside districts and States. Tiruchirappalli, East and West Godavari, Madurai and Salem were the main exporting centres. The exports outside the State which ranged roughly from 80 to 90 thousand imperial maunds were mainly to Mysore and from Godavari area to Nizam State, Orissa and North India.

Climate and soil.—Banana is a tropical fruit, intolerant to frost and requiring moisture. In this State where frosts do not occur up to a height of 5,000 feet, it can be grown up to that elevation. Certain varieties are adapted to particular climatic conditions as in the case of the *Sirumali* and *Virupakshi* on the hills, the *Chakrakeli* in the Northern Circars and the *Nendran* types in the West

DISTRIBUTION OF BANANAS IN MADRAS STATE.

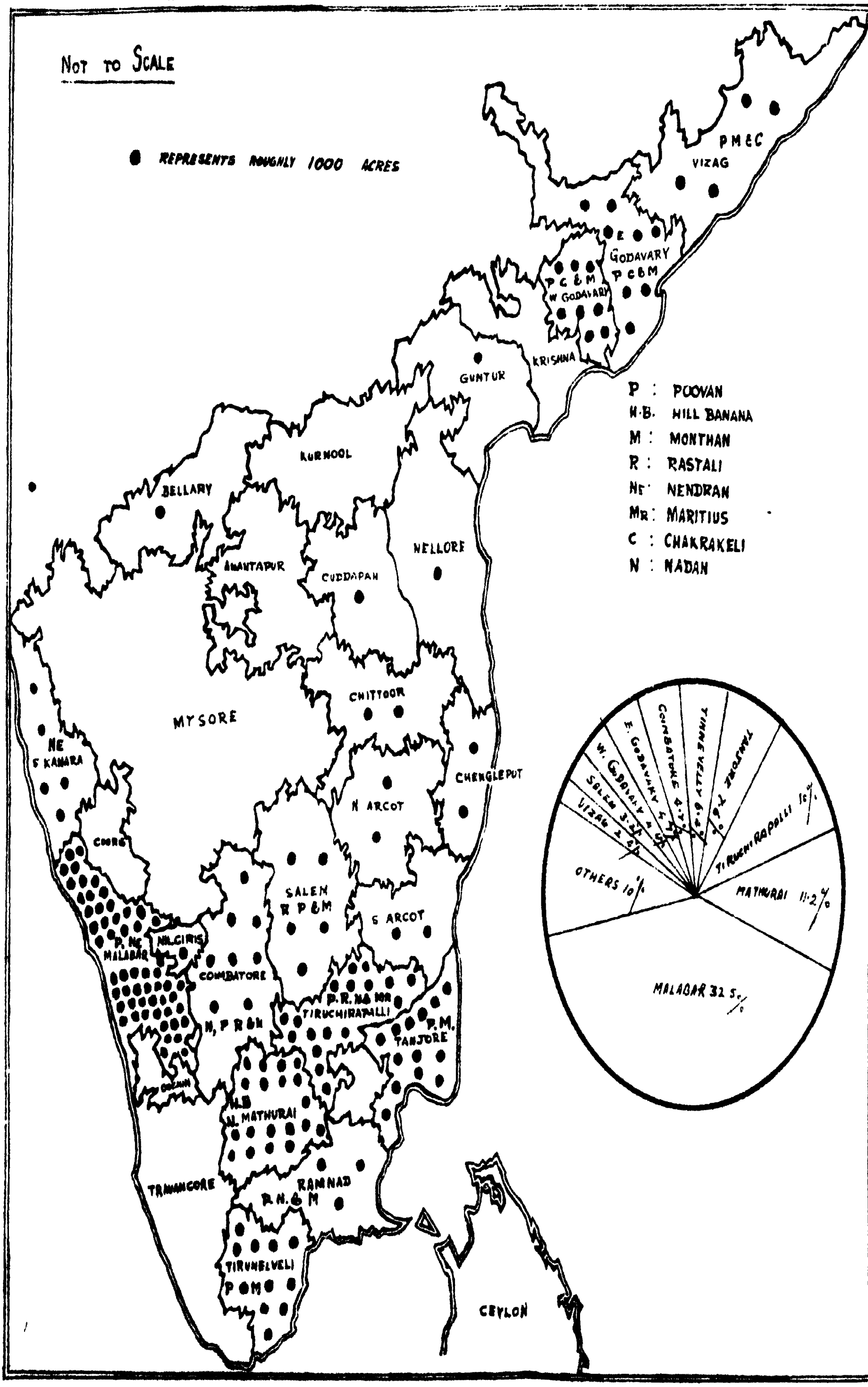

Plate 53.—Banana variety collection plot, Kallar Fruit Station

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Coast. It is one of the very few fruits which can be grown in wet lands, but requires good drainage. Banana can be grown in soils which are not deep enough for perennial fruits. It is also adapted to a variety of soils from stiff clays to light sandy soils, though very sandy coastal soils with low water-holding capacity are not suitable. Observations at Coimbatore have shown that the yields are better in garden lands than in wet lands. In Tanjore district "*padugai*" lands formed out of silt deposits are mainly the soils on which banana is grown and in Tiruchirappalli, wet lands are more favoured for the ease with which they can be irrigated.

Varietal introductions and trials.—Varietal studies of bananas from several tracts of the State have been made at Samalkot and the Central Farm, Coimbatore. Jacob has recorded detailed descriptions of almost all the varieties of South India and Venkataramani of culinary varieties.

Hybridization.—Hybridization is complicated in banana because the commercial types are sterile and produce no seed but develop their fruits without fertilization. There are such forms as *Musa malaccensis* which produce viable seeds. With their aid seeding should be induced in the commercial varieties, crosses effected and seedlessness again induced in the selected progenies. A few seeds obtained by crosses between some varieties at Samalkot have not germinated (1938–39). This evidently involves long and laborious work. For this purpose a Central Banana Research Station has been started at Aduthurai and the selected site has been taken over on June 1949 and a detailed programme of experiments has been drawn up.

Agronomic trials and experiments (Plate 53).—The most common method of propagation of banana adopted in this State is by suckers. The common belief is that 'sword-suckers', i.e., those with a tapering top are preferable to 'water-suckers', i.e., those with wider leaves. In a trial at Samalkot, it was observed that planting of older suckers resulted in certain earliness in the formation of the bunch, but it also resulted in a progressive deterioration in the weight of bunch with increasing age of the sucker.

The treatment given to the suckers before planting also is variable. The suckers may be planted soon after they are removed. They are sometimes topped at a height of 12 inches or even to a height of 3 inches only from the rhizome. The suckers are withered in shade for some days or even exposed to sun for a while. It was reported that dried suckers gave more robust plants than those from fresh suckers at Taliparamba.

Transplanting.—The usual seasons of planting in the Circars are June (*Tolakari*) and November to January (*Seethakattu*). Experience at Samalkot indicated that June planting is suited to varieties like *Chakkarakeli*, *Bontha* and *Mauritius*, while the winter planting is more suited for varieties like *Karpura Chakkarakeli* (*Poovan*) which take a longer time to bunch. In the West Coast, September to November is favoured. But wherever ample

irrigation facilities exist, plantings can be made at other parts of the year as well so that fruits might be produced at all parts of the year to fetch better prices. In Tiruchirappalli there are three planting seasons. On the Palnis the planting is usually done in April while in the perennial plantations in Tanjore planting is done from January to June.

Irrigation.—The hill bananas and the perennial plantations on the '*padugai*' lands in Tanjore are grown rainfed. In garden lands several methods of irrigation are employed according to convenience and tradition in the tract. The common methods are the basin system as is done for citrus, or by drain-*cum*-irrigation channels. The intervals of irrigation have to be adjusted with regard to the soil and rainfall.

Studies at Samalkot showed that by restricting irrigation, the flowering was slightly delayed and reduced, but bunches matured and came to harvest earlier. Weight of bunch and the number of hands and fingers in the bunch were reduced as also their keeping quality.

Culture.—Inter-cropping with vegetables and yams is done in certain tracts. Green manuring is not usually done, except in parts of Tiruchirappalli.

Propping with single or double bamboos has to be done to all tall varieties in the coastal tracts where heavy winds and cyclones usually occur. This can be avoided in the case of *Mauritius* which is dwarf.

Manuring.—It is common in several parts of the State to manure bananas before planting. In certain other parts it is applied two to four weeks after planting. A second dose of manure is applied in about five to six weeks. A third application may follow two months later. Elaborate trials on manuring banana have been conducted at Samalkot over a number of years which have led to the following conclusions :—

Increased applications of nitrogen have resulted in higher yields in the June planted crop but not so in the winter planted crop. This differential behaviour is attributed to the shorter duration of the crop under June planting, where the effect of higher doses of manure was felt. Increased doses of nitrogen have slightly increased the number of hands per bunch as also the number of fruits per hand, though not the weight of individual fruits. It has also slightly advanced the date of flowering, though the time taken to mature the fruits is slightly prolonged. The addition of potash and phosphoric acid did not have any significant effect.

It has been recommended that a suitable dose per acre of bananas may be a mixture comprising of 1¼ cwt. of potassium sulphate, 5 cwt. of groundnut cake and 2 cwt. of super-phosphate.

Pruning.—Pruning in banana consists of removal of suckers, hearts, dry leaves and mattocking or the cutting back of the old pseudostem after harvest of the bunch. After several observations, it was recommended that the retention of the third sucker was best

Plate 54.—Poovan banana in bunch P. 356

for replacing the mother plant, removing all the other suckers. This system is said to enable the harvesting of four bunches in a period of three years. The suckers have to be removed carefully with a *mammuty*. Workers in other countries recommend the removal of the suckers at their very emergence so that no plant food is wasted.

Growth, cropping and yields.—From the studies at Samalkot, it was observed that maximum growth occurs from July to November and the growth of the pseudostem ceases about two to three weeks before the emergence of flowers by which time most varieties attain a height about 100 inches while *Mauritius* attains about 56 inches. The bunch lengths vary from 12 inches in *Chakrakeli* to 24 inches in *Karpura Chakrakeli*. The time of flowering has been seen to be influenced by the variety, season of growing and the manuring and irrigation practices. The time of flowering and the time taken for the maturity are two independently variable characters and hence early flowering does not necessarily mean an earlier maturation of the bunch. It was observed that in the June planted crop 85 per cent of *Chakrakeli*, 83 per cent of *Bontha* and 75 per cent of *Mauritius* plants bunched by January. At Taliparamba, *Mauritius* was the earliest to mature taking ten months. The rainfed bananas grown on the hills take a much longer time to mature taking up to 18 months.

The weight of bunch varied from 18 lb. in *Nendran* to 40 lb. in *Mauritius* at Taliparamba. At Samalkot, *Chakrakeli* yielded 13,129 lb. per acre in 1924–25 while in 1926–27 it yielded 18,203 lb. *Poovan* is a very heavy yielder and high yields of about 10 tons per acre are reported from Tiruchirappalli (Plate 54).

Ripening, storage and products.—Ripening the banana can be hastened by smoking the bunch after harvest for 24 hours in summer and 48 hours in winter. On the Nilgiris, bunches are kept in pits and covered over with a plank leaving a small hole. The bananas are covered over with trash which is lit up diffusing the smoke in the pit. Smoking is also done in closed rooms in the consuming markets themselves.

It was observed at Burliar that application of vaseline to the cut end of the bunch stalk causes earlier ripening of the bunch and fosters uniform fruit colour. Insertion of ground garlic pieces in the fruit stalk was also found to quicken fruit ripening by about four days in Kodur. But the results have not been consistent.

At Samalkot it was observed that *Karpura-Chakrakeli* took four to eight days to ripen while it took five to seven days for *Chakrakeli*.

Karpura-Chakrakeli developed brown speckling four or five days after fully ripening while *Chakrakeli* developed speckling even before the bunch turned yellow.

Cold storage trials.—' Just mature ' and ' fully mature ' fruits of *Chakrakeli* and *Karpura Chakrakeli* were sent to Kirkee for study of storage life. It was observed that just mature fruits of *Chakrakeli* stored at 56° F changed colour after 12 days and

ripened fully in four weeks. The black spots developed fully in 37 days. Even when kept at 52° F it behaved similarly. The 'fully mature' fruits kept at 56° F remained green for twelve days and ripened in 25 days. *Karpura-Chakrakeli* 'just mature' fruits kept at 56° F and 52° F ripened after 19 days and began to rot a week later. 'Fully mature' fruits became ripe during transit and kept at 52° F for ten days in good condition.

Products.—As many as ten varieties of bananas were dehydrated with and without sulphuring. Judged by colour and taste, *Pey Kunnan* fig was of the best quality. Fig sample of four varieties, viz., *Pey Kunnan*, *Nendra Padathi*, *Ney Poovan* and *Kapur* were tested by the Processed Food Stuffs Directorate and all except those of *Kapur*, which had absorbed moisture, were approved.

Trials on the preparation of banana flour revealed that it was easier to prepare flour from unripe than from ripe fruits; *Nendran* appeared to be the best and most economical variety for preparation of flour; and the percentage of flour to fresh fruit in different varieties varied from 12·5 to 27·55.

Analysis of banana flour for food value showed that it was a good source of proteins and minerals and also contained vitamin B1 and could, therefore, be recommended as a food superior to tapioca, potato and arrow root. Trials on the preparation of biscuits and of a large number of Indian sweets, savouries and beverages from banana flour were successful. The Bio-chemist has also prepared jam out of bananas and standardized the product.

Banana fibre trials.—Preliminary work at Coimbatore in 1943 had indicated that banana fibre of a few varieties was of some promise as a substitute for abaca (fibre from *Musa textiles*). At the suggestion of the Director, Indian Army Ordinance Corps, certain large-scale trials with a number of banana varieties were carried out at Coimbatore with a Government grant from December 1943 to August 1945. In all 1,216 pseudo-stems from 72 cultivated varieties of bananas, two wild bananas from Anamalais and Wynaad and the abaca-yielding *Musa textilis* were utilised for fibre extraction. The extractions were in large part done by the hand method, consisting of stripping off the outer portions of each leaf stem in the form of ribbons, which were then drawn under a blunt knife that rests on a block of hard wood. The fibre was eventually dried in partial shade or in moderate sunlight. A summary of the results of these trials is presented below :—

(1) In point of yield, *Kuri Bontha*, *Pacha Nadan* and *Monthan* represented the most promising sources of fibre among the largely cultivated varieties.

(2) From the strength and quality tests conducted at the Technological Research Laboratories of the Indian Central Jute Committee, Calcutta, it was found that there were large variations among the samples of the same variety. However, in general terms, the strongest fibre-yielding varieties were *Kari Vazhai*, *Kali Ethen*, *Pey Laden*, *Giant Governor*, *Kuri Bontha*, *Nalla*

Bontha, *Tella Bontha* and *Nana Nendran*. Considering the general quality *Ney Mannan*, *Nana Nendran* and *Thella Bontha* were selected as the best. It was surprising to note that *Musa textilis* as grown in South India secured only a second place both in the matter of quality and tensile strength of fibre when compared to several of the cultivated banana varieties.

(3) In the matter of attractiveness of fibre which is an important trade requisite, considerable variation was found between the varieties. For instance, while *Kullan*, *Monthan* and *Elavazhai* yielded lustrous white fibre, that from *Nendra*, *Padathi*, *Booditha Montha*, *Bathees* and *Poovan* was greyish white and shiny and that from *Nana Nendran*, *Nalla Bontha*, *Krishna Vazhai*, *Kari Vazhai*, wild banana from Anamalais, *Pacha Montha*, *Bathees* and *Giant Governor* was greyish white and coarse. *Rasthali* fibre was silky to the feel, besides being greyish to pure white and shiny, while that from *Musa textilis* was light ivory yellow and coarse.

(4) The optimum stage for extraction of banana fibre appeared to be after the harvest of the bunch.

(5) Extraction trials in a few varieties indicated that the strongest fibre was obtained from the sheaths of the central folds of the pseudo-stems.

(6) Banana fibre did not show appreciable deterioration when immersed in water and saline solutions even after about six months. indicating thereby its suitability for use as marine cordage.

(7) Banana fibre was found suitable for rope and gunny making and for use as grafting bandages in fruit nurseries.

(8) From the trials it was indicated that the future of banana fibre industry depended largely on the successful devising of a cheap and simple extractor to increase fibre output far above that possible by hand extraction methods.

Dietetic and nutritive value.—Banana is one of the highly nutritious fruits supplying about 1·3 per cent protein and 36·4 per cent carbo-hydrate. It has also a high calorific value among fruits supplying 153 colories per 100 grams. It has already been said that the banana flour is an easily digested food that has been certified to be fit for invalids also. The banana is also a moderate source of vitamin B1.

Work of Research Stations and future research.—Detailed work on the description and nomenclature of banana was undertaken at the Central Farm, Coimbatore, and the variety collections maintained. At the Agricultural Research Station, Samalkot, several manurial trials have been conducted besides collecting some data on the varietal differences in fruit quality. A few crosses made showed that the seeds were not viable. At the Agricultural Research Station, Taliparamba, planting technique and observation on the performance of the varieties suited to the West Coast have been receiving attention. The Banana Research Station, Aduthurai, has just been started and is intended to take up comprehensive research for the improvement of banana.

Of the highest yielding fruits, banana is undoubtedly the most popular. It is almost an indispensable fruit in the household both for the table and the altar. As such, it is comparatively easier to popularize it as a substitute for part of the rice diet to relieve food shortage.

At present appreciable quantities of banana are being exported to parts of North India where banana is difficult to grow. With provision of better transport by way of refrigerated vans, larger exports from the State can be expected. The improvement of the fruit by production of new varieties having all the important economic characters is possible only through hybridization which takes a very long time owing to reasons already pointed out. Until such time, the production can be improved by selecting the varieties most suitable to each tract and by better manuring and irrigational methods.

Grape (*Vitis vinifera*).

Grapes are health-promoting fruits which do well for a dessert or in the fruit salads. The dried fruits are largely used in the household in several sweet preparations for the table. Preparation of the wine is not common in this country though it is an important industry elsewhere.

Area and importance.—Commercial viticulture in South India is confined to small areas in and around the villages of Michaelpatti and Pattiveerampatti in Madurai, Krishnagiri in Salem and Penukonda in Anantapur district and in Bangalore. Stray cultivation is found in parts of Tirunelveli and Coimbatore, on the hills at Kodaikanal and Ootacamund and also in the heavy rainfall areas like the West Coast. The area in this State under this crop was 250 acres, 150 acres being in Madurai and 80 acres in Salem and 20 acres in Anantapur. The production was estimated at 18,000 maunds annually which is about 4·8 per cent of the total production in the country. The produce is mostly consumed within the State while large quantities of dehydrated fruits from Baluchistan are being imported.

Climate and soil.—Grape vine has for long been supposed to be a temperate fruit, but the performance of grapes in Madras has been not only satisfactory but phenomenal in some places. The success seems to be due to the existence of adaptable varieties and the intensive cultivation and cultural practices. It is, for instance, known that heavy rains during the flowering and harvest seasons are a serious handicap to the production of good crops. The pruning season in the several tracts is so adjusted that the harvests are not caught in the rains. Thus in Bangalore where August-September are the rainiest months, it is desirable that the crop should be obtained in December to March and, therefore, the pruning is done in September and again in March.

The production of two crops a year also seems to be a feature of tropical viticulture. Owing to the absence of severe winter cold, it becomes possible to have a second growing season during

which flower bud formation may be induced by stoppage of irrigation and pruning following the harvest of the main crop. While in Nasik the second crop is avoided by pruning short and deblossoming in the rainy season, in Madras both crops are being harvested by suitably manuring the vines to get over exhaustion.

Soils.—Drainage is the main factor in the selection of a site for the cultivation of grapes. Some of the soils in Madurai where the maximum yields of grapes have been reported are gravelly and very open textured and poor in fertility. But this has been made up by heavy organic manuring given in the form of green leaf. Near Penukonda, clayey soils were reported to have been used for vineyards. In such soils, a good admixture of gravel and sand is considered helpful in promoting drainage.

Varietal introduction and trials.—The green *Pachaidrakshai* is the common variety grown in Madurai and Salem districts while the Blue is more common in Bangalore and Anantapur districts. The seedless variety which is having a rapid extension in Madurai district has been introduced some years ago from Baluchistan and seems to constitute two distinct varieties, *Bcdana* and *Speen Kishmish* or *Sultana.*

As early as 1941 there was a suggestion that grapes may be planted in dry lands where groundnut was used to be grown provided water for irrigation was available. Trials showed that *Kishmish, Haitha, Saibi, Tor* and *Alexandria* were unsuitable for cultivation at Kodur. It was observed that *Beacon, Bedana* and *Gros Colman* produced good quality fruits while *Lukfata* and white *Muscadel* showed resistance to attack of downy and powdery mildew respectively.

Agronomic trials and experiments.—The method of propagation in this country is through rooted cuttings. Mature wood of previous season's growth is selected from prunings and planted in pots or flat nursery beds. The rooted cuttings are planted out into the field in the next January when six to twelve months old. It is reported that in Salem, the cuttings are directly planted in the field and sometimes grafts are planted. A trial at Kodur showed that the graft can be propagated by the method known as ' yema ' grafting.

Pruning.—Pruning twice a year is a feature of South Indian viticulture because of the markedly rapid growth.

As the vines grow, the side shoots are frequently removed and when the vine reaches the *pandal* the growing point is nipped off. The side shoots are trailed off in the desired direction. Tendrils are removed periodically so that the shoots may not be fixed down to any position. The first pruning is done after the first bearing. The season of pruning varies from tract to tract, being December and June in Madurai, January and July in Krishnagiri and March-April and September-October in Bangalore. These seasons, adopted out of experience of growers, seem to be quite appropriate considering the rainfall of the tract.

The pruning technique adopted is very simple and consists in cutting back the previous season's shoots to four or five buds. The same number of buds are retained in both the seasons. In some vineyards, however, the pruning in the second season is to a slightly lesser number of buds, i.e., three or four. In this system the number of bunches borne on a vine is not regulated but goes on increasing from year to year till they are too many in number and cause exhaustion to the vine. It is suggested that 40 to 60 buds alone need be left on a vine, i.e., eight to twelve fruiting canes, all the other canes as well as the weaker growths above the number suggested being pruned off.

Manuring.—From a study of the manurial practice in the several regions of the State it is seen that grape responds very well to manuring, especially to organic manuring. The phenomenal yields of Madurai vineyards are largely due to the intense organic manuring. The manuring consists of 50 cart-loads of green leaves, 100 to 200 cart-loads of farmyard manure and occasionally other wastes like tannery refuse when they are available. A peculiar practice in Penukonda vineyards is to apply four visses of gingelly cake powdered and fermented in buttermilk. The rationale behind the practice has not yet been gone into.

Harvesting and yield.—In South India the first crop can be obtained even in 15 months from planting. The Agricultural Marketing Adviser to the Government of India estimated the yield in 1935 at Madurai as 7,000 lb. per acre. More intensive cultivation has since been adopted and yields are higher. According to a recent report from a leading viticulturist in Madurai he obtained a yield of 50,000 lb. in the first crop and 20,000 lb. in the second crop from the variety *Pachadrakshai* while the seedless variety gave 16,000 lb. and 8,000 lb. respectively. If these figures are taken, the yields are a world record.

Dietetic value.—The grape has long been known to be a healthy dessert fruit and a diet for sick people. It is a good source of glucose of which it contains varying proportions according to varieties. The grape is a moderate source of vitamins A and C and has also a trace of vitamine B1. The raisins, however, contain a substantial quantity of vitamin B1 besides being a rich in iron.

Work of Research stations and the future.—The possibilities of extending the area under the fruit are very promising from the view point of climate, soil and yield factors. But the area under grapevine at Krishnagiri is dwindling and even at Madurai where very high yields are obtained, growers seem reluctant to extend the area under the crop and are reported to be preferring citrus instead. The possible reasons for this might be the large capital required to start with, the short time within which the fruit has to be marketed owing to the poor keeping quality and the absence of facilities for refrigerated transport. Provided these latter difficulties are removed, progressive growers may take up more and more to its culture.

It is also necessary that well-laid out trials should be undertaken in the several regions of the State to explore the possibilities of viticulture in the other regions of the State. The methods of preparation of simple products like the raisins as a cottage industry should be popularised.

FIG (*Ficus carica*).

Fig cultivation has not made an appeal to the South Indian grower because of the perishable nature of the fruit and the absence of any organized industry for the dehydration of the fruit. Fig production is therefore limited to a few orchards and home gardens.

Area and importance.—The area under the fruit in South India may not exceed 250 acres in all. The only places in this State where the cultivation of the fruit has assumed some commercial proportions are parts of Anantapur and Bellary districts.

Climate and soil.—Fig, like the grape, is supposed to be a warm temperate zone fruit but by virtue of the adaptability of varieties it is thriving fairly well in several regions of South India. It likes an arid atmosphere, especially at the time of fruit development and maturity, but it requires ample supply of moisture by way of irrigation. The soil should be medium to heavy retentive in nature but well drained.

Varietal introductions and trials.—Of three varieties, *Large Black*, *Marseilles*, and an unnamed variety from Kalhatti introduced at Coonoor, fig *Marseilles* has been found to be more suited for cultivation under Coonoor conditions, and comes to bearing in the third year of planting, the plant yield working out to about 10 fruits in the first harvest. This variety bears pale green, white fleshed, medium sized fruits which have a slight reddish tinge at the centre and are sweet in taste.

Of the several varieties tried at Kodur, only the self-fruitful varieties like *Poona* fig have been found suitable for commercial cultivation. *Black Ischia* and *Brown Turkey* have not proved so successful.

Agronomic trials and experiments.—The fig is usually propagated by cuttings taken from mature one-year-old wood about one-half to three-fourths of an inch in diameter. They are first planted in flat nursery beds and transplanting is done within 6 to 12 months.

Suckers and layers are also occasionally used for propagation. Side-grafting on *Ficus glomerata* and *F. hispida* was attempted with success at Kodur. At Coonoor the propagation of fig varieties, *Marseilles* and *Kalhatti* on *Ficus palmata* stock by whip and tongue method of grafting was found to be successful. The growth of these grafts, especially of *Marseilles*, was found to be vigorous.

To determine the best season and method of propagation of fig *Marseilles* on *Ficus palmata* stock, a small scale trial was initiated. Every month two grafts and two bud insertions of this scion on *Ficus palmata* stock were made. The observation showed that

there is no bud 'take' during all the months, while grafting has been successful.

The planting is usually done in August and September. The spacing given varies very widely depending mainly on the severity of the pruning adopted. The spacing of 12 feet adopted in Anantapur and Bellary districts is quite suitable for the training adopted.

Training and pruning.—In this State, no training or pruning is done except the removal of dead and wrongly placed limbs. Such a practice induces development of long naked non-fruiting wood on several shoots. The tree also is mis-shapen and an uneconomic performer. More systematic trial is needed to devise a satisfactory method of training and pruning. Meanwhile notching such bare necks is suggested to make the plants more fruitful.

Harvesting and yields.—The common *Poona* fig grown in this State does not require caprification or pollination. But for varieties of figs which require pollination, a method of artificial pollination has been devised at Kodur. A wooden needle was thrust through the eye of the *Ficus glomerata*, the wild fig and then passed through the eye of the cultivated fig. This method was found to be successful.

The fig produces two crops in South India in July-October and February-May.

The average yield in the orchards at Anantapur is about 300 fruits per tree.

Storage and products.—It is reported that Poona figs kept well at 32°–35°F for a month.

The dried fig is a very popular product which can be developed as a cottage industry. The wild fig (*F. glomerata*) is said to give a powder on dehydration which can be used in the preparation of a cold jelly. When malted and roasted it is said to yield a valuable breakfast food (Naik, 1948).

Dietetic value.—The figs are a rich source of Vitamin A and iron. They also contain 17 per cent of sugar besides 1·3 per cent protein.

POMEGRANATE (*Punica granatum*).

Area and importance.—Pomegranate has always been held as a delicacy on the table, as also a healthful and medicinal fruit. The area under the fruit in Madras may be about 100 acres distributed near Vellodu and Dindigul in Madurai, Uthukuli village in Coimbatore and Penukonda and Madakasira in Anantapur district.

Climate and soil.—The pomegranate prefers cool winters and hot summers. But under South Indian conditions it exhibits a great adaptability from the plains to elevations of 6,000 feet. Even in its soil preferences it is not fastidious and does well in all types of soils. But heavy loams seem to suit it well. It is a hardy plant and stands pruning and is, therefore, occasionally employed as a live hedge.

Varietal introductions and trials.—Of the 15 varieties grown at the Fruit-Research Station, Kodur, the varieties going by the names *Vellodu, Paper shell* and *Spanish Ruby* were promising.

Agronomic trials and experiments.—Pomegranate is usually propagated by seed in the State; this method should be superseded by vegetative propagation methods for standardization of varietal characters. The most convenient method of propagation is by hard wood cuttings 10 to 12 inches long. They are first planted in nursery beds and transplanted a year later into permanent sites. The use of Seradix at Coonoor to improve rooting did not prove effective.

The rooted cuttings are planted from July to January according to rainfall in the tract. The spacing given varies from 15 to 20 feet.

Pruning.—Since fruits are borne on the terminal growth, the bearing region is progressively pushed farther and farther away from the base and the fruits hang on weak, long shoots tending to break them. To train the trees to shapely form and strong shoots, annual shortening of past season's wood is suggested. Removal of suckers and misplaced branches also forms an important item of work.

Harvest and yields.—The pomegranate comes to bearing in the second year and some times later. The peak month of harvest at Kodur is June. The yields per tree have been varying from 50 to 150 fruits. Split fruits often reduce the yields in some varieties. It is also believed that a certain amount of sterility exists.

The fruits are reputed to keep for a long time.

PAPAYA (*Carica papaya*).

It is one of the quick growing and heavy yielding fruits and compares with the banana in the matter of food production per acre, nutritive value and ease of cultivation. Unfortunately it has not yet found favour with the consumers of this country though in Ceylon, this excellent fruit is in great demand.

Area and importance.—The area under the fruit is not accurately available. Owing to the prejudices against the fruit there are few or no orchards growing this fruit exclusively on a commercial scale. But it is found in several home compounds all over the State. The area may be estimated to be well over 1,000 acres.

Climate and soil.—It is a tropical fruit and cannot tolerate frosts. It is found to grow up to elevations of 5,000 feet above sea-level. All regions of South India except the very high mountain regions are suited to its cultivation. Frequent cyclonic weather, however, may cause damage to the crop.

It is adaptable to a variety of soils but is best at home on rich loams of uniform texture and good drainage. Ill-drained conditions even for temporary periods cause serious damage and even sudden death.

Varietal introductions and trials.—Being propagated from seed, papaya cannot have true varieties, in the accepted sense of the term. But since certain types are met with, which are different from one another in well-defined characters, they have been popularly called varieties. Probably it would be less confusing if they are referred to as types.

Of such types tested at the College Orchards, Coimbatore, it was found that the seeds produced varying proportion of seedlings which were unlike the parents. But by continuous selection, it was found possible to reduce the off-types in the progeny to a minimum. *Honey Dew* (called in vernacular as Madhu Bindhu) and *Washington* were the most popular in the South. Several strains introduced from South Africa and tried at the Fruit Research Station, Kodur, have failed to thrive.

Evolution of strains—(1) *By selection.*—Since papaya is cross-pollinated and there is a good deal of variation in the progeny, it offers many possibilities of selection of types, but the fixation of the characters in a pure line is however difficult and maintaining the purity of the strain or variety after it is issued for extension is still more so.

At the Kallar Fruit Research Station, a local selection was made which had many desirable characters. It produced about 70 per cent of female trees in the progeny; the seedlings commenced flowering even in the third month; it bore up to 103 fruits per tree in the first year; the fruits were borne on the stem even at 18 inches from ground level. If these characteristics are fixed up to a reasonable measure this is an outstanding achievement considering the difficulties encountered in the evolution of strains in papaya. (Plate 55).

(2) *By hybridization.*—The sex variation of the papaya is complicated. There are primarily three forms of sex, the male, female and hermaphrodite. There are several combinations of these forms. Each of them gives a different sex segregation in the progeny which leads to confusion. The dioecious type which gives better quality fruits has the disadvantage of deteriorating easily owing to the inevitable cross pollination and the occurrence in the progeny of about half the number of male plants which find themselves into the garden since the sex cannot be detected in the seedling. The hermaphrodite type has, on the other hand, the disadvantage of bearing a large number of mis-shapen fruits unsuitable for the market.

(3) *By other methods.*—Trials have been conducted at Kodur, Coimbatore and Kallar to propagate papaya by vegetative methods in order to standardize varieties. Inarching, cleft grafting and side grafting have all been successful.

Attempts to graft papaya on the hill papaya (*Carica candamarcencis*) have also been successful opening possibilities of growing papaya at higher elevations where the hill papaya does well while the ordinary papaya cannot thrive.

Plate 55.—Papaya in Fruits (Budhar Long) Kallar Fruit Station.

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But the main difficulty in all these cases is the non-availability of enough scion material. Papaya does not branch profusely and notching to induce branching has not been an unqualified success. Further, the crop stands only for five years after which it has to be replaced and the number of plants required per acre for each planting is so large that grafting must wait for a very long time before it becomes popular.

Agronomic trials and experiments—Nursery.—The seeds after extraction are washed to remove the gelatinous covering and dried in shade. The seeds are best sown immediately after drying, in seed beds of convenient size. Four to eight ounces are usually required to give enough number of seedlings to plant an acre. The season of sowing may be any but the hottest months.

The seedlings will be a mixed population of about equal number of males and females if it is the ordinary diœceous type. Several beliefs exist that characters such as a straight tap root, vigour and such other seedling characters are associated with one sex or other. An instrument was also devised which, it was claimed, would detect sex not only in papaya or other trees but also in eggs as well. But all these have proved of no avail to know the sex in the seedling stage. That means, in the planted orchards about half the number of males will not bear any fruit. It is suggested that if four seedlings per hole are planted, the chances are that in over 90 per cent of the pits there will at least be one female seedling so that when they grew up, the female plant can be kept, removing the rest.

The seedlings are transplanted in about 75 days after sowing taking the usual care and precautions. The spacing given is eight to ten feet.

Irrigation, culture and manuring.—Care should be exercised in irrigating to see that excess of moisture at root zone and prolonged contact of stems with water are avoided. Trees which tend to grow tall and bear near the crown may be headed back to bring the bearing region closer to the ground. Shallow culture may be given.

Harvests and yields.—Papaya flowers in the sixth month usually, and the first fruits may be obtained in about 10 to 12 months and it continues to yield all the time afterwards, except in the colder months. The yields from a single tree may vary from 30 to 150 fruits. The weight of the individual fruit may be one to over 16 lb. The acre yields vary with variety, soil and climate. Yields of 30,000 lb. are common and 60,000 lb. have been also obtained. The papayas yield till a very late stage but commercial yields dwindle down after the fifth year.

Storage and products.—The fruit is not a good keeper and has to be handled very carefully in all stages. It is a delicious breakfast fruit. It can be canned. Papaya jam has been prepared at the Fruit Products Research Laboratory, Kodur.

The most famous product that is produced from papaya is the papain which has assumed a great commercial importance in our neighbouring country, Ceylon.

The industrial possibility of preparing papain from papaya juice was shown at the Madras Industrial Exhibition held in 1917. The following extract will explain the method of preparing papain :—

" Papain is a digestive enzyme acting on proteids and converting them into soluble peptones. In this respect it resembles the pepsin of the gastric juice but is superior to it in that the latter can act only in acid media, while the former can act in acid, alkaline or neutral solutions. The ferment can be easily obtained from the juice of the papaya fruit. Unripe fruits, as they stand in the tree, are pricked with a small knife when a milky fluid exudes which soon coagulates to a plastic mass. A fair quantity is thus collected from a number of fruits—the fruits themselves not being spoiled in any way—and then extracted repeatedly with water in which the papain is soluble. The liquid is filtered, evaporated at 50°C. in vacuo and the residue again dissolved in the smallest quantity of water. The enzyme is now precipitated by the addition of alcohol, filtered, dried at a temperature of 40°C, powdered and stored in bottles. The strength of the ferment can be determined by adding a small weighed quantity of it to a definite weight of coagulated white of egg to which a drop of toluene may be added to prevent bacterial action ".

Dietetic value.—The fruit is an important source of vitamin A and C and also several valuable minerals. It has very high digestive properties. The unripe fruit is used as a vegetable and when mixed with meat it softens it in cooking. Even wrapping meat in crushed leaves of papaya is said to be effective.

At the instance of the King Institute, Guindy, production of crude papain was undertaken at the College Orchards, Coimbatore in 1942. This product, valuable in the preparation of cholera bacteriophage, was in great demand during that year to combat the cholera epidemic. Nearly 30 oz. of papain were collected from 974 fruits and supplied.

Work of Research Stations and the future.—No correlation between sex and seedling characters has been found at the Fruit Research Station, Kodur. Inarching, cleft grafting and side grafting were successful at Kodur, Kallar and Coimbatore. Papaya which can commence bearing in 12 months and yield at 30,000 lb. per acre of good fruits has a bright future in the country. The existing difficulty about keeping up the purity of the types can be overcome by judicious selection of seed from the interior of orchards and by zoning of varieties in the different regions of the State. More demand for the fruit should be created. This is being achieved near urban areas and with educated people.

SAPOTA (*Achras sapota.*)

Area and importance.—The area under the fruit in Madras was estimated as 220 acres.

Climate and soil.—It is a tropical fruit but can be grown up to an elevation of 4,000 feet though good yields can be obtained up to a height of 1,500 feet only. Provided there is a supply of sufficient moisture at the roots, the tree can grow equally well in humid and arid conditions. It seems to prefer sandy loams but has been noted to come up well even in lateritic gravelly soils, the littoral sandy strips, as also in the clayey black cotton soils of Ceded districts.

Varietal collections and trials.—Of about dozen varieties under cultivation in the State, seven had been grown at the Fruit Research Station, Kodur, and the following were promising:—*Cricket Ball*, *Dwarapudi*, *Kirthabarathi*, *Calcutta* and *Pala*. There are different forms which go by the last name and it is more appropriate to adopt Pala at a group name. The pot sapota is a dwarf and precocious type that can be grown even in pots and for ornamentation.

Agronomic trials.—Propagation by seed, layering and 'gooteeing' and inarching are common. *Bassia longifolia*, *B. latifolia*, *Mimusops elangi* and *Mimusops hexandra* are all useful as root-stocks of which the last is most commonly used, the *Bassias* forming incompatible unions. Trials at Kodur have shown that side grafting of sapota is possible. At Taliparamba it was brought out that August and September are the best months for inarching giving cent percent success while side grafting in the same period gave only 33 percent 'take'. In Taliparamba top working inferior sapota trees by the slotted side grafting method used for mangoes gave a 50 per cent take. The grafting was done after loping off the limbs.

Harvests and yields.—Grafts commence good bearing in about four years. It fruits all the year round with peak harvests in February to June and September to October. At Taliparamba sapota came into flush and flower once in two months and fruits were available for harvest all the year round, except in September. The peak seasons were November–December and March to June.

The fruits are harvested when the colour immediately below the rind changes to a light hue.

A yield of 1,000 to 2,000 fruits per tree may be expected from the tenth year.

Sapota products are not popular and the fruit is much better liked as a dessert fruit. No attempts have been made in this country to prepare chicle from the milky latex as is done in the U.S.A. and Mexico.

The sapota is a hardy fruit which can be grown in varied conditions of soil and climate, with little care or attention and as such it is a fruit which should find a place in all orchards. The area is estimated to be making a steady progress.

ANNONACEOUS FRUITS.

Four species of Annona are grown in this State. They are so adopted to the various climates and soils in the State that at any given place we may cultivate one or another of these species. They are mostly grown wild and no figures of any reasonable accuracy are available regarding the area.

Climate and soil.—The *Annona squamosa* or the custard apple, the well known *Seethaphal* is a very popular fruit all over South India. It enjoys a hot and relatively dry climate but can be grown up to a height of 3,000 feet as also on humid hills slopes. It grows on the poorest of soils and rocky situations.

The bull's heart or the *Ramaphal* (*A. reticulata*) is less common but comes up in all situations in which the custard apple grows.

The soursop (*A. muricata*) a large ovoid fruit with spines is not very common in this State, though being a tropical fruit, there is no reason why it cannot be grown in the hot arid plains. Probably its unpopularity is due to its sweetish sour taste which is not relished in Madras.

The cherimoyer (*A. Cherimolia*) has been successfully grown up to elevations of 7,000 feet, and above 1,500 feet, it is held to be a delicious fruit by the Europeans.

Agronomic experiments.—The propagation is usually by seed. At the Fruit Research Station, Kallar, scions from a selected parent of custard apple were inarched on its own seedling, on bull's heart, soursop and an allied species *A. palustris*. Grafts on custard apple stocks set fruits in eleven months after separation of inarches.

Cherimoyer and soursop have also been similarily tried on the above rootstocks. Both of them have been precocious on bull's heart seedlings at Kallar.

At Coonoor the custard apple and bull's heart were not suitable rootstocks for cherimoyer.

A palustris gave 100 per cent take with cherimoyer scions while it gave 80 per cent on cherimoyer stocks in May and July operations.

A comparative trial of cherimoyer seedlings and grafts on their own stocks indicated that in the early stages, seedlings were found to be more vigorous than grafts.

Harvesting and yields.—The custard apple seedlings come to bearing in three to four years. There is a large variation from tree to tree in yield, weight of fruits and number of seeds per

fruit. The custard apple is in season from August to December. Sixty to seventy pounds is the average tree yield. The soursop also bears fruit from June to August. The bull's heart is in season from January to May yielding about 100 lb. per tree.

The cherimoyer is in season about December and bears about 100 fruits per tree. It is reported that in all the species of Annona, some difficulty in pollination exists which when got over may lead to better fruit set.

Products.—The sieved pulp of custard apple when boiled with three-fourths of its weight of sugar and 0.5 per cent gives a good jam with milk flavour.

When selections are made and vegetative propagation introduced the fruits may become more popular. Delicious products can be made out of these fruits which may capture foreign markets. Being hardy fruits which can be reared with little care, they may be grown on lands less suitable for other fruits.

JACK FRUIT (*Artocarpus integrifolia*).

Jack is a very useful fruit tree and grows almost wild. The trees usually attains a large size and hence no attempt is made to grow them on a field scale. The ripe fruit gives edible carpels while the unripe one is used as a vegetable. The wood is one of the choicest timbers of exquisite colour and is used in the manufacture of the musical instrument 'Veena'.

Climate and soil.—It thrives both in arid and humid zones but prefers a plentiful supply of moisture in the soil especially in summer. It requires well drained, rich deep soils of open texture.

Varietal trials and evolution of strains.—There are no recognized varieties though distinct types are known, one with soft flesh and the other with crisp and hard flesh. There are evidences of tree variation in the quality of fruit and yield and this affords possibilities of selecting strains. For this purpose selections from Burliar, Coimbatore, Puttur, Bodinaikanur, Kozhikode, Olavakode, Tanjore, Cuddalore and Madras, are under trial. A variety called Singapore jack was tried at all Research Stations, but has belied its reputation to yield within 18 months. The casualties have also been many.

Agronomic trials.—For perpetuation of varieties and strains, trials were conducted at the Kallar Fruit Research Station for inarching jack on its own seedling, on that of an allied species of *A. hirsuta* and an allied type called *Rudrakshi*. The methods of whip grafting, layering and rooting of cuttings treated with hormones all failed. Budding also has so far not indicated any success.

Cropping, harvests and yields.—The jack seedings commence bearing in about four to seven years. The season of harvest is

from March to July in the West Coast, April-September in hill slopes and June to August in the Circars. Some trees yield a small off-season crop. Individual fruits weighing 80 lb. have been known. At Taliparamba a plantation of 268 trees gave an average yield of 18·5 fruits per tree with a maximum yield of 250 fruits per tree.

The bulbs have been canned for the first time at the Fruit Produce Research Laboratory Kodur. A—2½ size plain can, 40° Brix syrup and pressure cooking at 240° F (10 lb. pressure) for 35 minutes in an autoclave were employed. The canned product was fairly good. The pH. of jack fruit is 4·6 and hence pressure processing is necessary.

PINEAPPLE (*Ananas sativus*).

Pineapple fruit is renowned all the world over for its good taste. It is capable of producing heavy yields and can be grown in the alleys of other widely spaced fruit crops especially in their prebearing period.

Area and importance.—It is estimated that pineapple occupies an area of 1,400 acres in the Madras State, distributed mainly in the West Coast and round about Simhachalam in Visakhapatnam district.

Climate and soil.—It is a humid tropic fruit but can grow in arid climates if irrigation is provided. Where the temperature rises high it is advisable to grow this crop in the shade of tall trees as in coconut or mango orchards.

Pineapple prefers a well drained soil of open texture with irrigation facilities. On the hill slopes it thrives with less care than on plains. In the lateritic hill slopes in the heavy rainfall areas of the West Coast the fruit has great possibilities of extension as a waste-land crop.

Agronomic trials and experiments.—Pineapple is usually propagated by basal suckers. Slips that arise below the 'apple' and crown and the crown slips that arise around the crown can also be used. A preliminary trial of the method of propagation by stem discs was undertaken at Kallar in 1948 with *Kew* and *Mauritius*. The germination was very poor in both the varieties and the few plants that germinated also failed to establish.

Harvesting and yields.—The plants yield in 12 to 18 months of planting suckers. They may yield two or three more crops on the same site after which they decline in yield and should be replaced. A trial of hormones to force earlier maturity has been instituted at Kallar with *Kew* and *Mauritius* varieties. The mean yield in Madras was about 5.5 tons per acre. This is small compared to other countries but if rainfed plantations are excluded from the average, the yield is likely to be appreciably more. The crop in the West Coast comes up in April-June while that in Circars is in season from June to August.

Products.—Canned pineapples are the most popular tinned fruits in the country. Methods of preparing the juice, jam, candy and canned product have been worked out at the Fruit Products Research Laboratory, Kodur. A Pineapple eye extractor which is of immense use in the industry has been devised at the Fruit Research Station, Kodur.

Dietetic value.—It is a good source of Vitamins A and C and contains a fairly large amount of iron. It is capable of giving juice on expression to make delicious and healthful drinks.

Discussion on future.—As a fruit that can be grown under varied conditions of climate and soil, and as an inter-crop during the prebearing period of the orchard, pineapple is a valuable crop. Being largely suited to the canning industry the fruit deserves to be encouraged on a wider scale.

GUAVA (*Psidium Guajava*).

Guava is a hardy fruit which can be cultivated with little care and is popular as a homeyard fruit. It is not esteemed as a dessert fruit probably because of its seeds which are considered to cause indigestion. The planting of orchards to seedless varieties might make the fruit more popular.

Area and distribution.—The area in South India is estimated at 2,500 acres. It has attained commercial proportions on the river banks in the Circars especially of the Sarada river and Krishna river and round about Hindupur in Anantapur district.

Climate and soil.—An arid and hot climate is preferable though it may grow also in humid situations. Well drained soils of open texture are required for its culture even though they might not be fertile. The commercial plantations in our State are usually found on sands intermixed with alluviums.

Varietal introductions and trials.—The existing orchards are all seedling trees and therefore of no recognized merit. There are mainly four groups of guavas, red fleshed and white fleshed, seedless and seeded types.

Of varieties from the Uttar Pradesh tried at the Kodur Fruit Research Station the following were found to be of some merit: *Smooth Green*, *Allahabad*, *Red Fleshed*, *Nagpur Seedless*, *Saharanpur Seedless*, *Hafsi*, *Chittidar* and Seedless and *Karela*.

Agronomic trials.—It was found possible to multiply the plant by layering, and inarching on its own seedling and also from suckers arising from roots. The root suckers are not desirable as propagation material, since injury is caused to the roots during their removal.

Irrigations, culture and manuring.—On the river banks where they are usually grown no irrigations are given. No pruning or training is done in the commercial orchards in this State. It has been found possible to train guavas as a cordon along wires when

they look evergreen, while yielding appreciable crops under care. It has been observed that guava bears on the current season's shoots arising on past season's wood. This suggests that heading back past season's growth up to three buds might induce better fruiting.

Harvests and yields.—Guavas commence bearing withinfour years. There are usually two crops in June–July and October-December. When the first crop fails owing to floods, the second season often extends up to February. A light third crop is also harvested from February to April.

The grafts and layers at Kodur were found to blossom in June-July and January-March. An eight-year old *Smooth Green* tree yielded 800 fruits. The Red Fleshed variety yielded 700, and the Allahabad 500 fruits per tree. The seedless varieties yielded far less—125 fruits per tree. On cordons, the yield of *Chittidar*, *Hafsi* and *Safeda* was only about 200 fruits.

Products.—Trials at the Fruit Products Research Laboratory, Kodur, showed that fruits with thick white flesh and small seed cavity give a good canned product that resembles the canned pears of commerce. Guava jelly is an excellent product. Guavas can be dehydrated to yield a powder rich in Vitamin C. At Kodur it took 20 hours to dehydrate *Nagpur Seedless* at 120°-130°F.

Dietetic value.—An analysis for Vitamin C of the following Kodur guava varieties by the Nutrition Laboratories, Coonoor, in October 1942 gave the following results :

Variety	*Vitamin C, mg./g.*
Saharanpur Seedless	3·1
Allahabad	5·8
No. 46	4·9
Smooth Green	2·8
Red Fleshed	4·5
Nagpur Seedless	4·5

The future.—This fruit, which is rich in Vitamin C, is easy of culture growing even under conditons of neglect and may become popular, if not for the table value of the fresh fruit, for at least the delicious jelly that can be prepared out of it.

ZIZYPHUS (*Z. Jujuba*).

Area and importance.—One of the few xerophytic fruits, it may be called the hardiest fruit of the warm arid plains. The fruits from the superior forms are eaten by the urban population while the inferior forms yield small fruits consumed locally by the poorer classes. The plant is also a host for the lac insect. The fruit is estimated to occupy about 500 acres in this State, mostly in the districts of Cuddapah and Kurnool.

Climate and soil.—Zizyphus is adaptable to any situation and tolerates a certain amount of alkalinity and water logging.

Evolution of strains.—Strains of zizyphus were evolved at the Fruit Research Station, Kodur, using rootstock available locally. The scions were, however, selected after a survey from trees free from attack of the fruit fly.

Agronomic trials and experiments.—It is found possible to bud Zizyphus successfully on its own seedling as also on those of *Z. rugosa*, *Z. rotundifolia*, *Z. Ocnoplia.* Shield budding is preferred to ring budding. Seeds of all these germinate slowly and transplant poorly. It is therefore advisable that the seeds be sown in *situ* and budding done later when the seedlings attain the required size.

Harvesting and yields.—The *jujube* bears in two years after planting. The fruits are harvested from December to April. The yields may be 5,000 to 10,000 fruits per tree per year, but most fruits contain maggots of the fruit-fly.

MUSK MELON (*Cucumis Melo*).

The musk melon is an important commercial fruit in the river beds in Cuddapah, Kurnool and Anantapur districts, especilaly in the villages of Sidhout and Chennur on the bed of the river Pennar.

Climate and soil.—This is an annual fruit, growing in the dry part of the year from December to June. The river sands seem to be the ideal soils for its culture. Attempts to grow them in the best garden soils are reported to have not given fruits of the same quality.

Varietal introductions and trials.—The varieties commonly grown in Cuddapah are the *Bathasa*, *Shertiat*, *Anar*, *Shiranjir*, *Hingan* and *Budama.* Thirteen varieties of melons were imported from Russia and tried at the Fruit Research Station, Kodur, along with local varieties, but they failed to thrive.

Harvest and yields.—The vines commence to flower in about 40 days from sowing and fruits mature in 70 to 80 days. Later sowings tend to mature earlier and earlier sowings a little longer. The fruits from the later sowings are reputed to be sweeter. In spite of the set of ten to twelve fruits on a vine only two or three are carried to maturity.

Products.—Musk melon has been canned both as cubes and as pulp. But further work on canning conditions is necessary as melons have an alkaline reaction and may require neutralization. Melon jam with or without lemon is an important article of commerce. A method of preparation of jam has been perfected by adding $\frac{3}{4}$ the quantity of sugar and 0·5 per cent tartaric acid. The quality is improved by adding shredded ginger or sliced lemon.

WATER MELON (*Citrullus vulgaris*).

Water melon is being grown usually in the same tracts where musk melons are cultivated.

Climate and soil.—The water melon is more adaptable to climatic conditions than the musk melon. It is grown during the same season as the musk melon. In the river beds where they are grown together, spots farther away from the midstream are usually selected for the water melon. Unlike the musk melon, water melons adapt themselves to garden land and hill soils.

Varietal introductions and trials.—The popular varieties in Cuddapah are the *Surai* bearing longer fruits and *Gota* bearing round fruits. There seems to be red seeded and black seeded strains in both the varieties. Another sparsely cultivated variety called *Mecca Tarbuz* is known for its keeping quality.

It is reported that of the five varieties from Quetta tried in the autumn of 1946 at the Pomological Station, Coonoor, the white, red and black seeded melons established well, while the *Zarda* and *Kharbooja* failed to thrive after fruit-set and died prematurely.

Evolution of strains.—From the above three varieties, seven distinct types based on the fruit characters were isolated. Of them two types proved to be worthwhile multiplying.

Agronomic trials and experiments.—February and March are found to be suitable months for sowing.

Harvesting and yields.—The water melon fruits take a little longer to mature than those of the musk melon, taking four to five months on the hills and three on the plains. Each vine yields three to five fruits and the maximum weight of a fruit obtained at Coonoor was 14 lb.

Products.—The cold pressed juice of water melon may be made into squash of good quality and preserved with sodium benzoate.

MINOR FRUITS OF THE PLAINS AND THE HUMID TROPIC ZONES.

There are a number of minor fruits grown in several parts of the State some of which can be popularised by systematic culture. Important aspects that have come up for study and observation are dealt with below.

MANGOSTEEN (*Garcinia mangostana*).

Of the minor fruits this is the most valuable and has great potentialities of becoming a commercial fruit in Madras. The fruits are delicious and keep for a fairly long time. Owing to the thick rind it can stand transport well and is suited for export. At present Madras holds the monopoly in the fruit and the total area is about 25 acres.

It is a humid tropic fruit growing at low elevations with a rainfall of more than 50 inches. There are no varieties. Fruits are supposed to set without cross pollination and the seeds are

also slightly polyembryonic. These two facts are responsible for the absence of variation in the seed progeny. At the Kallar Fruit Research Station, six trees of merit based on their yield in the main and off seasons and their resistance to the gamboge disease were isolated.

The germination of seed was found to be highest (70 per cent) if seeds freed of pulp are sown within five days of extraction. The casualties in transplanting are many and trials are in progress to reduce them to minimum.

Vegetative propagational methods such as tongue layering, cincturing, budding, side-grafting, inarching were all under trial on rootstocks of allied species and have so far not indicated success. The main difficulty seems to be that there is an initial success in the form of a high ' take ' but further extension growth is not made by the scions which finally wither off. Of the several species used as rootstocks, *Garcinia tinctoria* offers some promise of success.

Observations on extension growth showed that new vegetative growth contributes little to the crop borne in any season. It was also noted that vegetative growth commenced at the end of the crop season.

Pruning trials indicate that mangosteen trees are intolerant to pruning of shoots or of leaves.

The period from flower to fruit maturity is not constant in all seasons. The yields and bearing season depend on the weather conditions. Analysis of performance of trees and weather data showed that dry weather preceding fruit set favoured crop size. It has two bearing seasons with an average yield of 240 fruits per tree, the highest recorded yield being 500 fruits on one tree.

DURIAN (*Durio Zebithinus*).

It is a tall tree bearing fruits of the shape of a small jack fruit with whitish buttery flesh and a very strong smell often repulsive to those not accustomed to eat it. The seeds also are edible. The fruit can be salted and preserved.

Trials at Burliar showed that inarching on its own seedling would give a ' take ' of 50 per cent in September and January operations. Usually trees come to bearing at the twelfth year; although some at Burliar failed to bear even after this period. The tree yields about 50 fruits per year, each fruit weighing 1½ to 2 lb.

LITCHI (*Litchi chinensis*).

This popular fruit of North India, prized very much in China and Japan as fresh fruit or dried or canned product, is little known in this State.

Six varieties, namely, *Bedana, Deshi, Calcutta, Dinpur, Purbi* and *Rose-scented* have been tried at the Kallar Fruit Research Station. Of them *Deshi* and *Purbi* flowered for the first time six years after planting.

Propagational trials were carried out on all the six varieties. *Purbi* gave a rooting of 91·7 per cent by tongue layering in September and *Bedana* 70 per cent rooting in January operations.

Inarching on its own stock produced only a 30 per cent 'take'.

Softwood, semi-hardwood and hardwood cuttings failed to root when treated with Seradix compounds.

At Kallar and Burliar the trees blossom only once in December and the fruits mature in May, while it is reported that two crops are borne at Hessarghatta in Mysore State. The yields vary widely with seasonal factors and at Burliar averaged to 286 lb. per tree in 1945–46 but to only 93 in 1944–45.

AVOCADO PEAR (*Persea americana*).

(*Butter fruit or Alligator pear.*)

This fruit reputed in the United States of America and Mexico as a very nourishing fruit of high dietetic value producing larger quantities of food in terms of calories per acre than any other fruit is hardly liked in South India. The fruit is grown on the Shevroys, Nandi Hills, Lower Palnis, Courtallam and Kallar and Burliar.

Propagation by tongue layering gave 75 per cent success in January 1946. Inarching on its own seedlings gave 50 per cent 'take' in September 1946. Ordinary cincturing of shoots did not produce root primordia, but shoots cinctured on the tree itself, separated three months later and planted in the ground under etiolated conditions gave some signs of success. Budding trials by the modified Forkert method gave some slight indications of 'take' in the beginning but ultimately ended in failure.

Attempts to root cuttings at three stages of maturity as softwood, semi-hardwood and hardwood by application of proprietary products as Hortomone A, Seradix A, B1, B2 and B3 failed to give any success. Thus it would appear that the only feasible method of vegetative propagation of the fruit is by tongue layering.

The blossoms appear in March-April at Kallar and occasionally in November-December. The fruits ripen five months later. The long type is observed to be earlier by a fortnight than the round type. The yields of this fruit have rarely exceeded 35 lb. per tree in Madras.

CARAMBOLA (*Averrhoa carambola*).

The sour type of this fruit is a delicious substitute for tamarind in culinary preparations while the sweet type may be used

Plate 56.—Star apple tree.
Kallar Fruit Station.

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for drinks, jams, jellies and pickles. The pulp of immature fruits is reputed to remove stains from linen.

The usual method of propagation is from seed. At the Fruit Research Station, Kallar, layering gave a success of 67 per cent. The layers could be separated in 70 days. Inarching on its own seedling gave a take of 80 to 100 per cent in July and January operations, the latter month being preferable. It was also noted that inarched plants came to bearing within ten months of planting while seedlings took five years.

The trees yield throughout the year with peak harvests in January–February and September–October. The yields varied from 100 to 250 lb. in a year.

ROSE APPLE (*Eugenia jambos*).

This tree producing delicately flavoured fruits is found in both arid and humid tracts of South India up to an altitude of 4,000 feet. It is usually raised from seed which exhibits polyembryony giving a mean number of 1·33 seedlings per seed. Layering was found to be a success with this fruit tree. The trees blossom in January and the fruits mature in March-April.

Eugenia javanica.—Layering has been successful at Kodur and inarching on rose apple stocks was found feasible at Kallar.

Eugenia uniflora.—Popularly known as *Surinam Cherry*, it produces scarlet coloured fruits. It is grown at the Coonoor and Burliar Fruit Stations. It is found to stand clipping well and may, therefore, be suitable for live hedges. It is more or less a hill fruit coming up only above elevations of 1,500 feet. Trials of cuttings did not succeed.

STAR APPLE (*Chrysophyllum cainito*).

Propagational trials on this ornamental fruit tree conducted at Kallar indicated that tongue layering is a success. It yields fruits from February to March. (Plate 56.)

INDIAN GOOSEBERRY (*Phyllanthus emblica*).

This fruit reputed as a good source of vitamin C, has been dehydrated for use by the army in the form of powder, tablets and candies. It also forms the basic constituent of the reputed Ayurvedic preparation ' Chyavanaprash '. At Kodur the trees were observed to flower twice, in July and February. The second flowering usually does not result in any appreciable crop. The pickling of this fruit is quite common in this State while candying is often seen in the North.

OTHEITE GOOSEBERRY (*Phyllanthus distichus*).

It is fairly common in home yards with ribbed pale fruits. It is observed that the peak harvests at Kodur are obtained in January. Elsewhere it is reported to give two crops, one in April–May

and another in August-September. It can be put to similar uses as amla but not so popular.

BREAD FRUIT (*Artocarpus communis*).

Though coming up well in humid tropical zones, it can also be grown in arid tracts if cultivated near sheltered spots amidst thick vegetation and well supplied with moisture. There are seeded and seedless forms, the latter being preferred. It is more commonly used as a vegetable.

Studies at Burliar have shown that root-cuttings which may be six to eight inches long planted horizontally about half an inch deep in the soil during the monsoon season from the best source of planting material. If vertically planted the rooting is only 20 per cent. Root suckers arising by themselves are also used as planting material. The trees bear in about six years of planting and yield over 50 lb. of fruits per year on an average.

FALSA (*Grewia asiatica*).

A fruit of comparatively recent introduction, Falsa thirves well in arid and warm plains of South India. The small berries having a large seed are reputed to give a delicious beverage besides being a good dessert fruit. The fruits are in season in summer. Unlike in the Punjab, the plant seems to yield well without pruning at Kodur where a single plant that has not been pruned is giving heavy crops.

WOOD APPLE (*Feronia elephantum*).

The fruits of this common tree produce a jelly of a very good set. It has been used as a rootstock for Sathgudi.

HILL FRUITS.

Though Madras is primarily a tropical zone, there are some places on the hills which owing to their elevation resemble the climatic features of more moderate or what may be called warm temperate conditions. Attempts have, therefore, been made by individuals as well as by the department to grow the fruits of the temperate and warm temperate zones in these regions. The starting of the Fruit Research Station, Coonoor, at an elevation of about 5,500 feet had served as a trial ground for successfully introducing several fruits into the tract.

The areas under the hill fruits are very small, some of them being confined to the Research Station, but their importance lies in the fact that they are all fruits which have attained popularity in the civilised countries of the West and they will form a valuable addition to our fruit wealth especially in those regions of high elevation where fruits popular on the plains would not thrive.

There are vast regions on the several hills in the State such as the Kodaikanal, Nilgiris, Araku, which have not yet been explored for the possibility of fruit culture. The knowledge gained at the Pomological Station, Coonoor, may be of immense value in making these hill slopes productive and add to the State's fruit wealth.

APPLE (*Malus indica*).

It was estimated that the number of apple trees in the State during the year 1942–43 was about 2,400 grown in the Nilgiris, Shevroys and upper Palnis.

Climate and soil.—The apple requires a cold winter period like that existing in Kashmir or Kulu Valley. Such cold and wintry conditions do not exist in Madras and hence the crop does not possess the vigour or longevity as the Kashmir crop.

Soils of deep and uniform texture are suited to apple culture as for any other fruit crop. But their life being very short it seems not inadvisible to grow them on comparatively shallow soils.

Varietal introduction and trials.—From a trial of about 50 varieties introduced at the Pomological Station, Coonoor, mainly from Australia, the following eight varieties have been selected for commercial cultivation.

Early varieties (fruiting from May to middle of June)—(1) *Zouches Pippin*: A dessert variety immune to wooly aphis, not keeping well and therefore should be left on the tree till it is required for consumption.

(2) *Allsop's Early*—A culinary variety immune to wooly aphis.

Mid-season varieties (fuiting from the middle of June to the end of July)—

(3) *Irish peach* is a dessert variety immune to the wooly aphis and a prolific terminal bearer with three stages of blooming.

(4) *Carrington*: A dessert variety having a regular bearing on spurs and non-spurs in equal proportions and resistant to the wooly aphis.

(5) *Winterstein*: A dessert variety with a relatively rapid growth, pronounced non-spur bearer blooming in two waves, the first giving 95 per cent and susceptible to the woolly aphis.

(6) *Edward VII*: A culinary variety susceptible to the wooly aphis pest, a spur bearer producing fruits in two blooms of equal importance with large fruits having better cooking qualities than Allsop's Early.

The late varieties—(7) *Signe Tillisch*: A dessert spur bearing variety with large fruits reputed for their keeping quality even for two months after harvest, resistant to the wooly aphis but susceptible to pink disease.

(8) *Rome Beauty*: A popular dessert variety grown in Bangalore with a good keeping quality, bearing its fruits mostly on non-spurs about 20 per cent and highly susceptible to wooly aphis.

Evolution of strains—By selection.—Five promising selections from private orchards in the Nilgiris, viz., *Braddock's non-pareil, non-pariel of Russet, Paragon* and two unnamed selections as also two other selections, *American Mother* and *Delicious* obtained from Chaubattia are under trial.

By other methods.—The selection of rootstock for the apples on Nilgiris is mainly to induce resistance to woolly aphis. The usual stock employed is the root sucker of the Crab apple, but the combination on the stock proved susceptible to wooly aphis. Trials with quince, China pear, *Photenia Lindleyana*, loquat and *Prunus puddum* as rootstocks for apple did not meet with appreciable success. The Malling stocks though quite suitable as rootstock in other respects, were unsuitable against the wooly aphis.

Finally, the Merton stocks No. 778, 779, 789 and 793 were tried. Of the four, 779 and 778 have been found to be of great promise not only on account of their immunity to the pest but also on account of the greater production of suckers in the propagation beds and the promotion of early vigorous growth on the scions grafted on them. Hence, these two stocks are now being largely employed for propagation of the apple varieties on the station. In the production of rooted suckers, M. 779 gave a mean yield of 1·22 suckers per mother plant, followed by 779, 789, Crab and 793 with 1·12, 0·27, 0·25 and nil respectively.

A rootstock trial employing all the four Merton stocks and including the common crab seedling with varieties *Winterstein* and *Rome Beauty* is under way. With *Rome Beauty*, the preliminary growth increments recorded at the end of 45 months of orchard life, showed that *M.* 778 registered the maximum mean percentage increase in girth and *M.* 779 the least. The plants on all the *Merton* stocks continued to be immune to wooly aphis.

Agronomic trials and experiments—Propagational methods.—The bench grafting method, i.e., grafting on the root by the whip and tongue method, has given a 'take' of 90 per cent with the variety *Irish Peach* as scion. The method of side grafting gave a 'take' of 80 per cent. Saddle granting was not an appreciable success.

The methods of shield and flute budding produced a low 'take' of 26 and 20 per cent only.

The success of grafting was highest when performed during the month of December to March.

Planting.—The planting on the hills is done from July to January. The spacing may be adjusted according to the tree size and may be about ten feet for the varieties *Zouche's Pippin* and *Signe Tillisch*, 12 feet for *Garrington* and *Allsop's Early* and 15 feet for *Irish peach*.

Culture.—Frequent soil culture is neither possible nor desirable on the hills, because of the risk of soil erosion. One hand weeding during a dry spell in August and another in the beginning of summer is all that is necessary.

Plate 57.—Apple Winter stein. *Linseed oil spraying trials—1948.* P. 388

1. *Tree Unsprayed—Control.*
2. *Tree in fruit sprayed with 3 per cent linseed oil emulsion.*

Manuring.—The usual practice is to apply a mixture containing a bushel of cattle manure and one-fourth pound each of ammonium sulphate and super phosphate per tree till trees are three years old, double the quantity till they are about ten years and three to four times the quantity later on.

A green-manure crop like the *Tephrosia Vogelli* is recommended to be grown in the alleys in the rainy season and pulled out and buried when it is about to set seed.

Training and pruning.—The usual method of training adopted for commercial growing is the modified leader system but the cordon and espalier systems seem to be of some use in home gardens to combine utility with artistic effect.

The system of training of apples by what is called the cordon method, wherein two main branches of the trees are retained and trained laterally along a horizontal wire, has been found to offer some possibilities of an earlier forcing of yields especially with the variety, *Rome Beauty*, which yielded up to 11 fruits in the second year of planting.

No definite conclusions could yet be drawn with regard to the efficiency of pruning in increasing yields of apples.

The non-spur bearers do not respond to severe restrictions of growth and hence are not suitable for training as cordons as the spur bearers.

The pruning of apples is done in December for early varieties while late and mid-season varieties may be pruned in January.

The pruned shoots may be burnt to avoid spread of disease. A spray of freshly slaked lime at 1 lb. in 10 gallons may also be employed as a prophylactic measure.

Cropping and yields.—The apples flower in March at Coonoor and the earliest apple in the market is *Allsop's Early* which is ready by the end of April. Certain varieties, produce more than one crop of flower.

A three per cent emulsion of linseed oil when sprayed on certain varieties of apples like *Signe Tillisch.* and *Winterstein* during the dormant stage was found to break the dormancy earlier and led to an earlier blossoming and increased yield of nearly four to five times the normal crop. (Plate 57.)

Trials in thinning of fruit to increase size and yield conducted over two seasons with the variety *Irish Peach*, have shown that the operation leads to a severe restriction of crop size, the loss ranging from 11 per cent in the case of lighter thinning to as much as 83·7 per cent in the case of more severe thinning. The incerase in size of fruit has been very little and does not compensate the huge reduction in yield. The practice of thinning, therefore, with the object of increasing fruit size and yield in apple is not to be recommended on the Nilgiris.

The yields vary with the varieties averaging to about 24 lb. in *Allsop's Early* and *Irish Peach* and to about 12 lb. in *Signe Tillisch* and *Winterstein*. The maximum tree yield obtained in *Irish Peach* was 52 lb.

Dietetic value.—The apple is used as a dessert fruit only by the rich. But the demand for this fruit has been great enough to induce foreign imports and from North India. No products are prepared in this country out of the apple. The healthful properties of apple have been summarised in the well known saying 'An apple a day keeps the doctor away.' It is a fair source of vitamin B-1 besides having small quantities of vitamin A and C.

PLUM (*Prunus salicina*).

Area and importance.—The Japanese plum has yielded well in the climate of Coonoor and it seems possible to make it a commercial fruit of some importance in the region. But it has not been as popular as the apple because of the more perishable nature of the fruit besides being liked by fewer persons. It was estimated in 1942-43 that there are about 2,000 plum trees in Madras producing 50,000 lb. of fruit per year.

Varietal introductions and trials.—Of the 35 varieties of plum tried at Coonoor the following have been selected as being of merit :—

(i) *Dessert varieties*--

Early : (Fruiting in the last week of April) *Rubio*.

Mid-season : (Fruiting about the end of May) *Gaviota* and *Hale*.

Late : (Fruiting from 1st June to middle of July) *Shiro, Abundance, Czar, Kelsey, Satsuma, October Purple, Hale*.

(ii) *Culinary varieties*—

Early : *Alu Bokhara*. (Plate 58.)

Mid-season and late : *Hale*.

Of the dessert varieties named above, *Hale* has been found to be the most productive dual purpose variety, blooming in three or four successive waves from the second week of February to the first week of March and is therefore to be recommended for extensive commercial planting. (Plate 59)

Czar and *Gaviota* yield fruits of fine eating quality and are fancied greatly as dessert fruit while *Shiro*. *Abundance Kelsey* and *Satsuma* may be classed as fair dessert types. Rubio with its sub-acid taste makes a favourite culinary fruit while *Alu Bokhara* valued for its prolific bearing and earliness in the season is a good stewing variety.

Rootstocks.—The common peach has been found to be the suitable rootstock for all varieties excepting *Czar* and *Gaviota*. Plum seedlings, and the East Malling stocks, *Marianna*, *Brompton* and *Myrabolan* were tried but gave only poor percentage of success.

Plate 58.—*Plum—Alu Bokhara in bloom* **P. 391**

Plate 59.—Plum "Czar" on common peach stock.
Note the swelling at the trunk showing the incompatability of the stock and scion. P. 392

One observation has, however, been made that the budded plants of plum on plum seedlings were strong and vigorous when compared with the plants budded on common peach. To obviate the incompatibility seen at the bud union in the case of *Czar* and *Goviota* plums budded on common peach and to select a compatible stock for these two varieties a rootstock trial has been laid out. The growth increments made by the scion trees so far showed that with *Gaviota* as the scion, the maximum growth in respect of scion girth and height was recorded on *Rubio* stock followed by common peach and least on *Hale*. With *Czar* as scion the maximum growth was recorded on common peach stock while there was no appreciable difference among the other stocks.

Trials of *Prunus divaricata* as alternate rootstock to common peach on *Rubio*, *Hale*, *Alu Bokhara* and *Combination* for six years revealed that this stock is of doubtful utility for plum under Coonoor conditions.

Growth performances of seven plum varieties, viz., *Czar*, *Hale*, *Shiro*, *Alu Bokhara*, *Abundance*, *Rubio* and *Gaviota* on common peach stock have recorded the largest growth increment in scion girth in the case of *Shiro*, followed in order by *Abundance*, *Hale*, *Gaviota*, *Rubio*, *Alu Bokhara* and *Czar*. In the cases of *Gaviota* and *Alu Bokhara*, the increment in stock growth has out-stripped that of the scion.

Agronomic trials and experiments.—Studies in the germination and growth of common peach and plum seedlings have shown that the percentage of germination of the plum is considerably less than that of the common peach whose rate of growth is also less. The maximum germination recorded was 3·6 per cent with *Hale* seedlings as against the average of about 10 per cent with the seeds of common peach.

The shield method of budding has been found successful for propagation of plum, and has helped to reduce the nursery costs considerably. Trials with *Shiro* and *Gaviota* scions showed that the shield method was superior to flute, the difference in success obtained by the two methods being as high as 38 per cent in favour of shield budding. January was found to be the best month for budding.

Planting.—The spacing given to palm plants depends on the spread which the variety might attain. It varies from 12 to 20 feet. November to January is the period not suitable for planting plums on the hills.

Training and pruning.—The usual method of training of Japanese plums at Coonoor is the open-centered type. In varieties like *Hale*, the tree should be helped to grow a little upright. *Rubio*, *Hale*, *Gaviota* and *Early Jewel* have been trained to cordon system of training and are under observation.

Trials at the Pomological Station, Coonoor, have shown that indiscriminate and severe pruning of plum trees year after year leads not only to progressive deterioration in yield but also to gradual decrease in the vegetative vigour of the trees. Annual pruning at least should be confined to the removal of dead and diseased shoots and inter-crossing limbs and to an occasional tipping of excessively bearing branches. By adopting the latter method, a two fold increase in yields in some of the heavy bearing varieties has been obtained.

Studies have also shown that the varieties differ from each other in the extent of crop borne on the laterals. Laterals are important because they bear the sprigs. Heading back the laterals leaving a stub annually is a harmful practice and should be resorted to only once in five or six years when the yields decline. The pruning season at Coonoor is December and January.

Cropping and yields.—Flowering in plums commences in December and continues up to March in late varieties.

A peculiar characteristic of plum production is the phenomenon of self-infertility of certain varieties. The only way by which such fully or partially self-sterile varieties can be made to bear is by planting these in conjunction with varieties which are suitable pollenizers.

Pollination studies have led to the following tentative conclusions:—

(1) Pollination with *Alu Bokhara* pollen resulted in fruit set of 9·3 and 10·3 per cent in *Rubio* and *Satsuma* seedlings respectively while the selfed flowers of the latter two varieties by themselves recorded a fruit set of 6·5 and 10·3 per cent respectively, thereby proving that while *Satsuma* seedling is self-fertile, *Rubio* is only partially self-fertile and its fruit can be increased by about 3 per cent by a suitable pollenizer like *Alu Bokhara.*

(2) *Hale* was found to be a uniformly suitable pollenizer for *Gaviota, Abundance, Shiro, Combination, Kelsey* and *Czar*, the fruit set recorded in each in the order given being 6·4, 5·9, 2·6, 15·4, 3·3 and 1·9 per cent respectively. *Hale* by itself when selfed recorded a fruit set of 11·1 per cent.

(3) *Kelsey* proved compatible with *Abundance, Hale* and *Combination*, the fruit set in each of these crossed with it amounting to 4·6, 21·4 and 12·5 per cent respectively.

In order to find out if the yields from a self-sterile variety like *Shiro* can be improved by top working the same with a good pollenizer like *Hale* and *Satsuma*, a small observation trial was laid out during January 1948. While *Hale* branches flowered and set fruit within a year of top working, the *Satsuma* branches failed to set fruit during the same period. This indicates clearly an appreciably closer affinity of *Shiro* with *Hale* than with *Satsuma*. A record of the fruit set in the *Shiro* tree in the immediate vicinity of the tree top-worked to *Hale* showed a mean tree yield of 50

as compared with only nine in the trees with no pollenizers in their midst. This clearly indicates the advantages of top working inherently self-infertile varieties like *Shiro* to a suitable pollenizer like *Hale* in order to increase yields.

Fruit thinning trials with a number of varieties have been conducted for a period of nearly five years with prolific varieties like *Rubio, Alu Bokhara* and *Hale*. The trial consited of thinning the fruits to leave a spacing of one or two inches between any two fruits. With the variety *Rubio* results were somewhat successful and an increase in size as well as volume of fruit in the case of one inch thinned trees to the extent of nearly 40 per cent over unthinned trees, has been recorded. Although the results in the case of this variety have been conclusive of the benefits of fruit thinning similar trials with *Alu Bokhara* gave directly opposite results. There was not only no increase in fruit size but the gross yields were also reduced by nearly 50 per cent when thinned. The differential results obtained with the two varieties lead to the conclusion that the benefits of thinning are largely dependent on the variety concerned. A similar trial has also been initiated on the variety *Hale* where permanent thinning of the fruit bearing spurs is done instead of an annual thinning of the fruits borne on them. The analysis of the results showed that there was no perceptible increase in the size of fruit due to thinning of spurs.

Observation of yields showed that there is no biennial bearing tendency in the plum even though large variations of yield occur from year to year. The yields also vary with varieties averaging about 70 lb. per tree.

Products.—Four varieties of *Prunus domestica*, viz., *Splendour, Sugar, California d'Agen* and *Giant* were tried at Coonoor of which *Splendour* was found to give good prunes. A sample of prunes dehydrated by the Biochemist at Kodur, was declared to be of fair quality and could be reconstituted well in hot water.

THE PEAR (*Pyrus communis*).

Area and importance.—Compared to apples and plums, pears are more popular in Madras. They are of better keeping quality than plums and cheaper in cost which probably account for their popularity.

The pears require an elevation of 5,500 to 7,000 feet above sea level and do better around Ootacamund than at Coonoor. It was estimated in 1942–43 that the area in the State was about 710 acres of which 557 were under the country pears while the rest of the area was under superior varieties.

Varietal introductions and trials.—From the trial of 20 varieties at Coonoor, *Kieffer* pear alone was found to be suitable.

The name 'country pear' is a misnomer as it is not indigenous to the country though found in a semi-wild state. Being in

common use as a rootstock for other varieties of pear it is more appropriately called the stock pear.

Four selections have been made from private orchards which are under observation.

Propagational methods.—" Whip and tongue " grafting on stock pear rooted cuttings has given the best results among the propagation methods tried, giving almost a cent per cent success.

For getting the maximum success in rooting of stock pear cuttings, splitting the base of the cuting, inserting a wedge between the splits and smearing a layer of cowdung over the tips of the cuttings have given the best results.

The cuttings are generally planted on a small raised ridge with spacing of nearly six to nine inches between the cuttings.

Trials indicated that the optimum period for planting stock pear cuttings for rooting was the last week of September wherein a maximum of 95·84 per cent success in rooting was obtained.

Shield budding of pear has given only a ' take ' of 48 per cent and hence whip grafting is preferable.

Some trials on top working on the *China pear* by cleft and whip grafting have indicated a great success recording a mean shoot length of six feet in three years, besides inducing earliness.

Planting.—The most favourable months for planting was January.

Training and pruning.—The pear is usually trained to the vase shape. The pruning adopted is similar to the one adopted for apple. The months of pruning are December and January.

Pear orchard may be inter-cropped with strawberry, Cape gooseberry or tree tomato.

Cropping and yields.—Pear trees flower from January to March and fruits are ready for harvest from May to September, *Kieffer* being the last to come to harvest.

The degree of self-sterility of varieties seems to be influenced by climatic conditions in the pear. *Kieffer* is reported to be self-sterile in some situations. Of the varieties at Coonoor, *Williams* and *Beurre Giffard (Plate* 60) are said to be good pollenizers while *Jargonelle* is a defective pollenizer besides being unsuitable for commercial growing. It seems desirable that two or more varieties should be planted together for providing pollen for one another.

The mean yield of *Kieffer* at Coonoor was 72 lb. per tree with a maximum of 110 lb.

Storage ripening and products.—The fruits picked when they are easily separable from the spur are to be ripened by keeping them in closed boxes. Under such conditions *Kieffer* pears ripen in about a fortnight developing a golden yellow colour and becoming soft.

Plate 60.—Pear ("Beurre Giffard") trained to the P. 397
"Caldwell" system, Pomological Station, Coonoor.

Plate 61.—Peach "Killikrankie" in bloom, Pomological Station, Coonoor. P. 399

Plate 62. – "*Killikrankie*" *and common peach trained to cordons. Pomological Station, Coonoor.* P. 400

Trials at the Fruit Products Research Laboratory, Kodur, have produced a good canned product from pears. Country pears have hard flesh with a tendency to show up brown spots due to bruises.

PEACH (*Prunus persica*).

Area and importance.—The peach comes up in the same climate as the plum but certain varieties are adopted to higher and lower elevations also. No definite statistics are available regarding its area since the tree is rarely grown on orchard scale on the Nilgiris. It was estimated that the annual production of peaches in 1942–43, was about 31,800 lb. of fruit which would probably have been obtained from over 800 trees.

Varietal introductions and trials.—Of over twenty varieties tried at the Pomological Station, Coonoor, *Shanghai seedling*, *Killikrankie* (Plate 61) and *Sha Pasand* are the varieties which have recorded satisfactory performance. *Killikrankie* is a moderately sweet cling-stone type but is an early bearer, hardy and fertile. This blooms twice, first in December and again in January. *Shanghai seedling* is a larger fruited variety that comes to bearing late in the season. This blooms early in March. *Sha Pasand* is an introduced variety from Quetta giving sweet but no juicy fruits (Plate 62).

Propagational methods.—The common peach seedling has proved to be the most suitable rootstock for propagation of the peaches. The percentage of germination recorded with the common peach seeds does not usually exceed more than 15 per cent at the most. Attempts to increase the percentage of germination by sowing stones instead of seeds did not result in any appreciable success, because while the stones gave a slightly higher percentage of germination the time taken by the stones for complete germination was abnormally long, nearly nine months, as compared with that taken by seeds which usually germinate in about four months after sowing. Hence the practice of sowing seeds instead of stones is to be recommended for raising peach seedlings.

Shield budding without wood has given better results than flute budding. January and March proved to be the optimum months for the insertion of the buds. Trials conducted with stocks of eight months, 20 months and 32 months old, budded with *Red Shanghai* and *Shanghai seedling* varieties gave the highest bud take of over 80 per cent with 20 months old stock. It has also been noted that here is a direct correlation between the girth of the stock and growth of the scion in the nursery. In other words, the thicker the rootstock the faster is the growth of scion wood during the early stages of bud sprout development.

Planting.—July to January is the period favoured for planting as for other fruits on the hills. It is usually planted at a spacing of 15 feet. Being a precocious bearer it is often planted as filler in pear orchards.

Training and pruning.—The usual method of training in orchards is to the vase shape. But it is amenable to cordon or the fan shape in which form it may be useful near the boundaries and in home gardens. The *Killikrankie* peach trees trained to cordon did not give consistent results but *Shanghai seedling* similarly trained was better. The effectiveness of the cordon system of training seemed to depend on varieties and on other environmental factors.

The pruning of bearing peach trees consists of annual shortening of growths to force new wood on which fruit is borne. Observations at Coonoor have shown that shoots of the past seasons growth more than 11 inches long form fruitful wood. Trial of two treatments, namely, (i) tipping shoots longer than 11 inches and cutting hard shorter shoots and (ii) cutting only hard short shoots leaving the longer ones alone, were conducted at Coonoor for over two years on varieties *Killikrankie* and *Shanghai seedling*. In both cases the unpruned trees gave more yield than the treatments, though in the variety *Shanghai seedling* the pruned trees produced greater length of shoots than the unpruned.

Cropping.—Peach bears in two to three years from planting. The *Killikrankie* flowers as early as November-December while *Shanghai seedling* flowers as late as March at Coonoor. Consequently the former fruits are available in May and the latter in July. The peach yields at Coonoor have ranged from 15 to 20 lb. per tree in the *Killikrankie* and *Shanghai seedling*. Trees trained to cordons have yielded about 20 fruits even in the first year of planting. In the third year the common peach gave about 50 lb. while the *Killikrankie* yielded 11 lb.

PERSIMMON (*Diospyros kaki*).

Though classed as a sub-tropical fruit, it is coming up well at Coonoor. The fruit is almost confined to the limits of the Pomological Station.

Varietal introductions and trials.—Of the four varieties tried, viz., *Dai Dai Maru*, *Tanenashi*, *Hyakume* and an unnamed variety, *Dai Dai Maru* and the unnamed variety have been found to come up better than the rest under the local conditions. The former variety is a dependable cropper blooming in March and harvesting in the latter part of September and has recorded a maximum yield of 34 lb. per tree. The fruits are orange red and glossy with slight bloom. The unnamed variety develops a very sweet flesh when ripe and is also a consistent and dependable cropper. This also blooms in March. The fruits are deep red and glossy. A maximum yield of 96 lb. per tree has been recorded.

Propagational methods.—The multiplication of persimmons by seeds has not been possible since almost all the fruits are seedless. The seeds, if any, are not viable. Hence to raise the rootstock

seedlings for propagation of persimmon, seeds and root suckers of a number of species of *Diosproys* have been tried and the results are summarised below.

Seeds of three wild species, namely, *D. ebenum*, *D. tomentosa* and *D. chloroxylon* obtained from Cuddapah failed to establish even though a few seeds in each of them germinated.

Seeds of *D. lotus* obtained from Japan and grown at monthly intervals in well prepared beds and pots recorded a maximum percentage of germination of 45 in January followed by 24 in April, 21 in March and only 16 in February. Sowings in beds gave a higher percentage of germination of 23·4 as against 2·8 recorded by seeds sown in pots. Seeds obtained from U.S.A. did not germinate except one, and even that succumbed within a fortnight of its germination.

Attempts to layer the shoots and to raise rooted cuttings by cincturing soft wood as well as hard wood shoots and by the application of rooting hormones have all failed to yield any result.

Pruning.—The pruning of persimmon is a subject on which divergent views are held. It is reported that in China the current year's bearing wood is heavily headed back. Observations at Coonoor have indicated the desirability of stimulating new growth. A pruning trial with the variety *Dai Dai Maru* conducted over a period of seven years has shown that heading back two-year old shoots in the first year and tipping past season's shoots in the subsequent years led to an increase in yields ranging from 17 to 22 per cent and an increase in new growth flushes of 13 to 21 per cent. It seems safe therefore to recommend pruning for persimmons as a general orchard practice under Coonoor conditions.

Cropping and yields.—Persimmons commence bearing from about the fifth year. They blossom in February and fruits are harvested in September. There are both monoecious and dioecious trees. Sometimes they bear perfect flowers also. It is reported that the variety *Tanenashi* produces all pistillate flowers and seedless fruits. Several other varieties are also reported to develop fruits without pollination though sporadically they may produce staminate inflorescence. It is however suggested that staminate flowering trees should be planted about one in eight trees in persimmon orchards.

Storing and curing.—The fruits of all varieties grown at Coonoor are astringent and are difficult to ripen naturally. Investigations have shown that a simple method of ripening them is to keep them in association with other fruits like ripe pears, tomatoes, bananas, mangosteens, passion fruit, tree tomatoes and Cape gooseberries in air-tight containers for three to five days. The ripening process was quickest when fully ripe fruits of tomatoes and *Keiffer* pears were used. The quantity of the Catalytic fruits used had no effect in influencing the time taken for ripening persimmon.

STRAWBERRY (*Fragaria sp.*).

This is one of the bush fruits which is quite at home on the Nilgiris and it has been possible to produce fruits all through the year. It is a very attractive table fruit owing to its colour and delicate flavour (Plate 63).

Varietal introductions and trials.—An early trial of *Royal Sovereign* and Baron Solemacker failed to produce any fruit. The type under cultivation for more than ten years on the Nilgiris is a mixture of varieties in which *Royal Sovereign* is found to predominate. One difficulty however with this fruit is its very low keeping quality.

Evolution of strains.—Large variations in yields were seen to exist between individual plants, the range being no yields at all in some plants to a maximum of 71 fruits per plant in the best yielder, with a mean yield of 27 fruits per plant. The yield records of the clonal progenies of 100 selected plants giving 35 pickings over a period of 16 months showed no correlation between the yields of the parents and the progenies in the first or the second generation.

Agronomic trials and experiments—Propagational methods.—The strawberry is propagated from splits of clumps or runners. In a small scale trial to study the relative efficiency of splits as compared to runners used for propagation it was observed that while 95 per cent of the splits established themselves, only 65 per cent of the runners did so. The first flowering in the former commenced 76 days after planting as compared to 135 days in the latter. New growth was more vigorous from splits than from runners. The use of splits is therefore to be preferred to the existing practice of planting runners for raising new plantations under Coonoor conditions. Splits from three-year-old mother plants gave 39 per cent more yields than those from one year old, while the corresponding runners gave only 6 per cent increased yields. Hence the propagation of strawberry is best done by splits from three-year-old mother plants rather than by runners or splits from younger plants.

Planting.—While planting splits, it is better to lightly prune the tops and the roots prior to planting them in the ground, as by this treatment an increased yield of 32·5 per cent has been obtained over unpruned splits. Plants spaced at one foot by one foot gave highest yields. They recorded 122 and 55 per cent increased yields over those spaced at two feet by two feet and one and a half feet by one and a half feet respectively.

In Japan, transplanting strawberry twice is recommended to promote differentiation of flower buds. This was tested at the Pomological Station, Coonoor but the results were not in favour of a second transplantation.

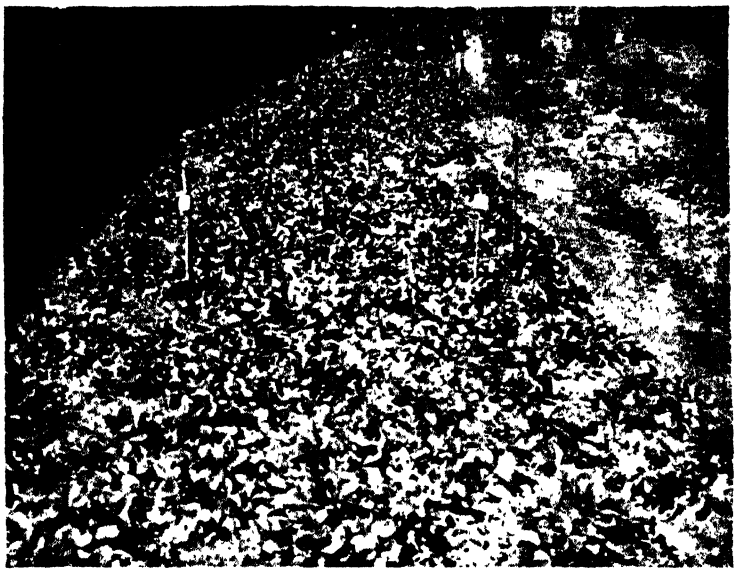

Plate 63.—A view of the Strawberry progeny trial plot P. 465
Pomological Station, Coonoor.

Irrigation.—On the Nilgiris irrigated crops of strawberry have been found to be far superior to rainfed crops.

Manuring.—Plants manured individually at the rate of 10 lb. of well rotten cattle manure while planting recorded an increased yield of 21·5 per cent over those for which an equal quantity of manure was broadcast in the field.

Culture.—Being a shallow rooted crop the culture should be light. A mulch with straw or any available leaves or ferns is usually provided in January or when flowering commenced to conserve moisture as also to prevent the shoots touching the ground. The old decaying leaves of the plants should be stripped off periodically. The plants flowering very soon after planting may also be deblossomed. It is also necessary to remove runners if they are more than four in each stool.

Cropping and yields.—The usual season of flowering is from December to March, the fruits coming to harvest between February and July. It is also possible with care to produce fruits throughout the year except the cold months. The average yield was about 25 fruits per stool.

The fruits are very perishable and they should therefore be picked on alternate days when the fruits are well coloured but still firm with the calyx attached and a portion of the stalk intact.

CAPE GOOSEBERRY (*Physalis peruviana*).

A hardy shrub, the cape gooseberry is found to grow both on the plains and the hills of Madras up to an elevation of 6,000 feet. It is also highly adaptable to varied soil conditions and even relatively infertile areas. The fruits are pleasantly acidic containing numerous tiny seeds. It is also very useful in the manufacture of jams.

Varietal introductions and evolution of strains.—The variety grown on the Pomological Station, Coonoor, was originally introduced from South Africa several years ago. As in the case of strawberries large yield variations were noted from the yield records of selected plants maintained. The yield varied from no yield to 227 fruits per bush. This suggests the possibility of selection of high yielding strains.

Agronomic trials.—Propagational trials by tongue layering and rooting of cuttings by several means including the use of rooting hormones were not successful. But in 1949 cuttings treated with a proprietary hormone, Saradix BI gave a rooting of 76 per cent. The usual method of propagation is from seed, the seedlings being transplanted when 6 to 8 inches high. They may be grown in flat beds or raised on the sides of ridges. The crop is irrigated once after planting and rainfed afterwards.

Cropping and yields.—The plants flower in the first year of planting usually in November about twelve months after planting

at Coonoor. It is reported that in Araku valley plants from seeds sown in July flowered in the following October and the fruits were ready for harvest by March. An acre yield of 30,000 lb. is reported to have been secured in Araku valley.

PASSION FRUIT (*Passiflora edulis*) AND (*Tacsonia mollisima*).

These fruits are found to thrive very well at Coonoor. The name passion fruit is said to have been derived from the flower parts which are supposed to be a symbolic representation of the Cross.

Climate.—The vine fruits only at higher elevations while at elevations of 2,500 feet or below it is seen to run into leaf.

Varietal introductions.—There are purple fruited as well as yellow fruited varieties. The variety which has given an encouraging performance at Coonoor is the purple fruited variety. Seeds of an edible variety of passion fruit from Hawaii, *Passiflora ligularis* failed to germinate. Seedlings of yellow passion fruit variety obtained from Ceylon (Peradeniya) also failed to establish.

Agronomic trials.—The usual method of propagation is by seeds. But stem cuttings gave a rooting of 32 per cent. The cuttings were precocious coming to bearing in four months.

Cropping and yields.—The seedlings come to bearing in ten months and yield about 12 lb. per vine. The maximum yields are obtained in the sixth year. The fruit is borne on new wood indicating that periodic pruning of laterals may help in improving yields.

Storage and products.—Because of the hard shell, the passion fruit can stand transport well. When kept long it may shrivel and become less attractive but the quality is unimpaired.

Passion fruit squash of 55° brix containing about 33·3 per cent of the fruit juice is an excellent beverage. Opinions received from District Prohibition Officers indicate that it can be useful as some kind of healthful substitute for intoxicating drinks. The squash preserved with sodium benzoate is far superior in taste and flavour to that preserved with potassium metabisulphate. Since passion fruit can be grown very quickly a small passion fruit squash industry may be built up in the State. The fruit can also be used to make jellies and spreads.

APRICOT (*Prunus armeniaca*).

Four varieties, namely, *Frogmore Early*, *New Large Early*, *Red French* and *Moor Park* have been on the Pomological Station for the past fifteen years and only two trees in each of *Red French* and *Frogmore Early* came to bearing for the first time yielding only eight and seven fruits per tree respectively. The fruits are of good quality. Propagation by budding on common peach stock has given promise of success.

WALNUT (*Juglans regia*).

Four seedlings of an unknown variety are at the Pomological Station, Coonoor. Their performance is not promising and they have not yet come to bearing. A few plants of the *Khagzi* variety introduced from Kashmir in 1947 also failed to establish.

Walnuts growing in the Nilgiris tract are of very poor quality. It may not be worthwhile paying much attention to this crop at present for the following reasons: (1) General experience indicates that walnut does not give its best on the Nilgiris. (2) It takes a long time to come to bearing. (3) The male and the female phases of the tree are separated by about a month and unless there is an appreciable area under the tree, likelihood of adequate fruit set is remote.

FEIJOA (*Feijoa Sellowiana*).

It is an ornamental bush growing at elevations higher than 1,500 feet. The oval fruits, dull green in colour, often blushed dull red on one side, and containing numerous tiny seeds, are useful for jam and jelly making. The fruit is aromatic but can be eaten when fully ripe. Seeds from varieties obtained from Hawaii and sown in 1948 failed to germinate. Propagation may also be done by cuttings.

The plants come to bearing in the fourth year after planting. The fruit set being very low attempts made to indicate better set by hand pollination were successful. The fruits are harvested from September to December.

RUBUS *Sp.*

Raspberry.—The plants of raspberry introduced from Chaubattia were prolific in sucker production but the yields have been very little and disappointing. Its extension, therefore, is of doubtful utility. This plant is usually propagated by root suckers. Propagation by the method of tip layering has also been successfully attempted. A success of 60 per cent has been recorded from the shoots tip layered in September and October 1949.

Blackberry.—The progress of the variety introduced from Chaubattia has been promising. Root suckers produced were separated and planted out. Three of the older plants gave nearly 2 lb. of fruits per plant in the second year of cropping. The maximum number of fruits counted on a plant was 332. Tip layering also is being attempted and so far 25 per cent success has been obtained from September and October operations in 1949.

CHAPTER 9.

VEGETABLES.

Production—Area, importance—Indigenous vegetables—Root crops, the potato—work at the Agricultural Research Station, Nanjanad, on potato—varieties and evolution of strains—The sweet potato and tapioca—Onions—Production for seed supply at the Agricultural Research Stations—Seed supply organization in Madras City.

Importance.—'Vegetables' is the term collectively used for stems, fruits, leaves, seeds and other moist succulent parts of plants used as auxiliary or subsidiary articles of food, either raw or cooked. They are rich in vitamins and mineral salts and help to make up the normal deficiencies of these ingredients in the staple foodgrains and pulses. They are thus essentially of the nature of protective foods and are of great value. They are bulky in nature and provide roughage for stimulating and promoting healthy bowel action. It has been estimated that a daily intake of six ounces of non-leafy vegetables and 4 ounces of the leafy kinds by an adult would meet the nutritional requirements under South Indian conditions.

Production.—The area under the various vegetables is estimated to be 2,48,700 acres in the Madras State representing 0·7 per cent of the total area under cultivation. The annual production of vegetables is 1,000,000 tons and gives a *per capita* consumption of 46 lb. per year. This is a fifth of the nutritional requirements, at the 10 ounces level per head per day. The normal areas under the important vegetables are given below :—

Indigenous vegetables.	Extent of cultivation in acres.
Brinjals	37,000
Ladies fingers	7,000
Gourds and pumpkins	23,000
Greens	3,000
Radish	2,000
Cluster Beans	3,000
Other beans	3,000
Curry plantains	13,000
Tomatoes	5,000
Miscellaneous	5,000
Total	101,000

Root crops.	
Sweet potatoes	34,000
Onions	47,000
Tapioca	33,000
Yams and colocasia	10,000
Total	124,000

Exotic vegetables.	Extent of cultivation in acres.
Potato ..	20,000
Cabbage	1,800
Beans ..	1,000
Peas ..	800
Carrots	200
Turnips	400
Brussel's sprouts	100
Knol-khol	150
Others ..	250
Total ..	24,700
Grand total ..	248,700

The cultivation of vegetables received a great impetus during the years 1943–45 when various schemes sponsored by the Agricultural and Defence Departments were in operation for meeting the requirements of the defence services. These schemes were worked successfully and the production of vegetables was increased. Indigenous vegetable schemes were run at Salem, Buchireddipalem, Nagari, Coimbatore, Poonamallee, Visakhapatnam, Ettarai, Mangadu and Hiranyamangalam, exotic vegetable schemes at Hosur, Kodaikanal, Coimbatore and the Nilgiris and onion schemes at Palni, Tiruchirappalli and Visakhapatnam. The increases in production were very great under certain categories and bore no relation to what prevailed before the war. After the cessation of hostilities, these schemes were closed one after the other and there was a fall in production, but not to the original level. There was a general rise in the levels of income and expenditure caused by the war conditions and these are being maintained more or less. There has also been a shortage of food supplies in the country and the consumption of vegetables is in general much more than in the pre-war years.

Vegetables are broadly classified into 'Indigenous' or 'Indian vegetables' and 'Exotic' or 'English' or 'European' vegetables. The indigenous vegetables are more or less native to the country and are tropical vegetables. The exotic vegetables were introduced in to the country by the European settlers and travellers at various times, in the recent past. They are mostly of subtropical origin and thrive in a mild and equable climate.

Irrigation and season.--Vegetables are generally grown under irrigation. When however, rainfall is heavy and well distributed, vegetables are grown under rainfed conditions as in Malabar, South Kanara, Visakhapatnam and the Nilgiris.

There are definite seasons of planting for most of the vegetables when they come up well and better than out-of-season and there are other vegetables that do equally well almost all through the year, without being season-bound. Most of the vegetables are preferred to be sown in '*Adi-pattam*' and '*Masi-pattam*' in the southern districts, corresponding to August and March respectively. '*Maga-karthi*' (15th of August) is the season similarly preferred

in the northern districts. Besides these, there are special seasons suitable for the several vegetables individually. Vegetables are also planted out-of-season to cater regularly to the consuming markets; the yields are generally low in these out-of-season plantings and the produce is sold at high prices. Potatoes and exotic vegetables in the hills, sweet potato and tapioca in the west coast, Bellary onions in the Ceded districts and the small types of onions, in the Circars, Tiruchirappalli and Coimbatore districts are instances of some vegetables which have their own regions of concentrated production. The common vegetables are produced throughout the State, wherever irrigation facilities and markets exist. Information is furnished in the following sections on the work done on some of the important vegetable crops.

Potato.—Potato is one of the tuberous vegetables introduced into this country a little over a hundred years ago. It is palatable, lends itself to being made into most of the South Indian dishes and is popular with all classes of consumers. It keeps well for months under proper storage and can be handled and transported over long distances for disposal over large sections of the country. It is therefore popular with the cultivator and the merchants who handle the produce.

The pioneer work of introduction and trial of potato was done at the Government Botanical Gardens, Ootacamund and continued up to the time of establishment of the Agricultural Research Station, Nanjanad.

The normal area under potatoes in this State is 19,500 acres and more than 90 per cent of the crop is grown in the Nilgiris. The other centres of production are the Kodaikanals of the Madurai district, the Shevroys in Salem district, the Anamalais in Coimbatore district and the Araku valley of the Visakhapatnam district. The annual production of the crop is estimated at 73,000 tons.

The potato thrives well at elevations over 3,000 feet where cool and equable temperature and evenly distributed moderate rainfall conditions prevail. It can also be grown in plains with moderate elevation as at Hosur during the cold weather period, October to February. The crop stands temperature ranging from 80° F on the high side at 40° F at the lower end, without the setting in of frosty conditions. The crop requires moderate rainfall and is not able to stand either long spells of drought or heavy rainfall over 30 inches during the growing period. The crop does well in rich friable red loams, which are moderately acidic, and which do not have a high lime content.

The land is well prepared, manured with eight to ten cart-loads of cattle manure and 10 to 15 cwt. of concentrated manure mixture and laid into ridges and furrows 14 inches apart. Seed tubers weighing about one ounce each are planted in the furrows eight inches apart and five to eight bags of tubers weighing 1,000 to 1,500 lb. are required for planting an acre. Two hoeings and an

earthing-up are done later. The crop is dug when the haulms turn yellow. The tubers are left exposed to the atmosphere to dry out and shed the adhering earth. The tubers intended for consumption are stored in dark rooms to prevent them from turning green and getting unfit for cooking.

The Agricultural Research Station, Nanjanad.—This Research Station was started for the improvement of potatoes in the Nilgiris. (Plate 64.) A large number of varieties of potato were obtained from United Kingdom and Australia and grown in the main and second crop seasons. One of the introductions, '*Great Scot*' which matures early has become the standard variety of the Nilgiris and is popular with the growers, merchants and consumers. (Plate 65.) It has round medium tubers, smooth white skin, flat eyes, hard flesh and a cosmopolitan range. '*Royal kidney*', '*Kerrs pink*', '*King Edward*' '*Golden wonder*' and '*Bressie*' are some of the varieties grown in small areas here and there in the Nilgiris.

Improvement by evolution of strains.—Potato is propagated by planting tubers. The tubers, obtained from plants that produce the largest number of medium sized tubers are planted separately to induce increases in yield. This method called the 'hill selection' was tried to evolve high yielding potato strains. The improvement in yield was not however marked. Different varieties of potatoes that flowered were crossed and the seeds obtained were used for producing new hybrid varieties. Many exotic varieties were imported from other countries and used for hybridising. Some hybrids obtained from the potato and wheat Breeding Station, Simla, were also under trial. The hybrids produced or tried at Nanjanad, have so far not proved to be definitely superior to the standard '*Great Scot*'. Certain buds developing from the mother tubers are very rarely different from the parent stock and exhibit characters not possessed by the original parent. These new types or 'Mutants' that were noted at Nanjanad were also not better than the parent stocks. Attempts are being continued to produce better varieties.

The first crop or the main crop of potato is planted in March in the Nilgiris and harvested in July, the second crop is planted in September and harvested in December and the third crop is planted in January and harvested in April. The tubers are spread out in racks and kept for some months to induce sprouting and the sprouted tubers are planted. The fersh tubers are not useful for planting, and the tubers of one season are kept over in storage during the next crop season and used for planting in the season following it. The irrigated crop is harvested in April and the tubers are kept over for planting the second crop in September. The area that could be irrigated is limited and sets a limit to the seed material available for planting the September crop. The produce of the main crop harvested in July does not produce sprouts

Plate 64.—Agricultu al Research Station, Nanjanad. A Panoramic view. P. 415

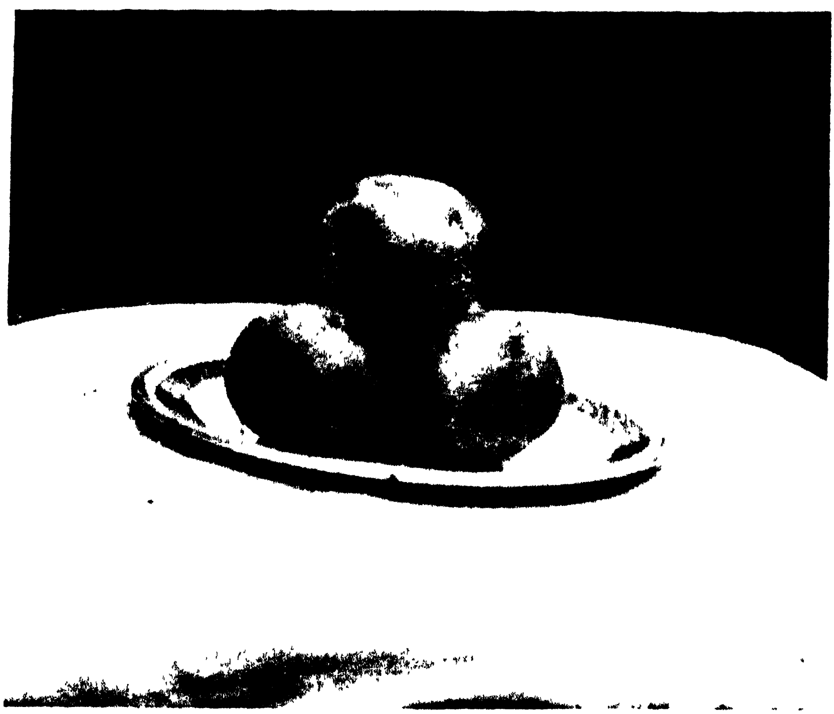

Plate 65.—Potato—Great Scot. Most popular variety. P.416

by September, and cannot then be used for planting. Various methods were tried to induce the fresh tubers to put out sprouts. When potato tubers were treated with carbon disulphide against the attack of the potato tuber moth, it was noted that the treatment helped to break the dormancy of the fresh tubers and induce quick sprouting. This is now adopted for inducing sprouting in fresh tubers immediately required for planting when supply of seed potatoes is scarce. Other chemicals tried were not so effective as carbon di sulphide in breaking the dormancy of the potato tubers.

Small-sized tubers (chats) are used as planting material by the cultivators usually. Trials show that the yield increases with the size of the tubers used for planting. Planting tubers weighing about two ounces each six to nine inches in rows spaced 27 inches apart is found to be the most economical. Cut seed tubers do nor do so well as entire tubers, and if at all tubers have to be cut for planting, the cutting should preferably be done longitudinally through both the distal and crown ends. The cut tubers should be dusted with sulphur or treated with formalin or mercuric perchloride to prevent fungus damage. While planting, the cultivators place the tubers flat with the distal and crown ends on the sides and this is a sound practice.

Potato is an exhausting crop and requires heavy doses of manure in the Nilgiris. The soils are acidic and the iron and alumina contents of the soil are high. They act on the soluble phosphates applied as manure and immobilise a large part of the phosphates. A portion of the applied phosphates alone is absorbed by the plants, and it is, therefore, found necessary to apply much more of the phosphates than what is actually required for plant absorption. Even so, the soluble phosphates like super phosphate give a better yield than insoluble phosphates like steamed bone meal. The Nilgiri soils are also deficient in potash, and organic matter and these have to be supplied in the shape of manures in sufficient quantities. Potato responds well to nitrogenous manuring. Taking all these into consideration and the cost of the fertilising ingredients, a suitable fertilising mixture was evolved for the potato crop at the Nanjanad station. It is called the 'Nanjanad potato fertiliser mixture' and contains 500 lb. groundnut cake, 350 lb. steamed bone meal, 200 lb. ammonium sulphate, 336 lb. concentrated super phosphate, and 224 lb. of potassium sulphate. The mixture containing 5 per cent nitrogen, 13 per cent phosphoric acid and 7 per cent potash, and 1,610 lb. of the mixture would be a suitable dose for an acre of potatoes. The manure mixfure may be applied along with ten cart-loads of cattle manure at the time of forming ridges and furrows for planting the crop. Municipal compost can be substituted for the cattle manure. But it is best to retain the ingredients of the fertiliser mixture at the levels indicated. Various proprietary manure mixtures prepared by several manure firms have been compared with the 'Nanjanad Mixture' and found to be not so efficient. The insufficiency of certain rare elements like cobalt, manganese, nickel, copper, etc., in the soil are known

to affect the productivity of crops in a remarkable manner. So far as is known the absence or insufficiency of rare elements in the Nilgiris is not affecting the productivity of potatoes.

Various pests and diseases affect the potato crop and potato tubers in storage. Tubers were treated with acorus, derris, pyrethrum, tobacco, D.D.T. and Gammexane dusts and the incidence of the potato tuber moth was noted. Tubers treated with acorus and tobacco had the least attack from the moth while the other observations were not very indicative. The potato wilt is caused by *Rhizoctonia* species (fungus). Stray plants dry up in the field and the disease spreads over the field gradually. The dried up plants require to be removed and burnt to prevent the wilt. infection spreading. Dark spots appear on the leaves of immature plants occasionally and is referred to as 'Early blight'. It is not a serious disease. When the disease appears in the early stages of growth spraying with Bordeaux mixture is effective in controlling the disease. "Ring" disease appears in an epidemic form in certain seasons and is caused by a bacterium. The plants are affected in the late stages and start drying up after the tubers are formed. On the tubers being cut, irregular dark rings are seen on the cut surface. The best that can be done is to uproot the affected plants and burn them up with the tubers to prevent the infection spreading. A high acidity of the soil keeps the disease in check, while a fall in acidity promotes the incidence of the disease. Virus diseases are also seen, but they are not of major importance now in this country.

The potatoes are harvested by digging with a *mammooty* fork, locally known as *guddali*. Where the potatoes are extensively cultivated, the use of potato digger ploughs drawn by cattle is efficient and economical. The potatoes are graded in a rough way into (1) kidney, (2) medium, (3) *rasi*, (4) *podi*, (5) *thallu* or rotten, damaged and cut. The potato can be graded easily into different sizes with a mechanical potato grader designed by the Agricultural Research Engineer. Seed potatoes are stored in well ventilated rooms on racks. Table potatoes are stored in heaps in dark rooms. Potatoes exposed to light develop a green colour and get unfit for cooking. When the potatoes are heaped the tubers in the centre of the heap develop a dark colour in the centre of the individual tubers and lose their keeping qualities. This is referred to as 'black heart'. This could be avoided by providing perforated ventilating vertical shafts in the store room and heaping the potatoes round these shafts. These shafts help to draw in cool air from outside and reduce the temperature of the room.

The cultivation of potatoes in the plains has not developed, but could be done during the cooler months of the year from October to February. Suitable varieties have to be found and seed material arranged to be produced in the Nilgiris for supply to the plains. Varieties like '*Rangoon Rickets*', '*Hosur Rickets*', '*Italian White*' may possibly do well in the plains.

Plate 66.—A crop of Bellary onion, Agricultural Research Station, Hagari. P. 420

Sweet potatoes and tapioca.—It was only in 1946 that attention was focussed on sweet potato and tapioca as subsidiary food-crops which could be utilized for supplementing the cereal food-grains that were in short supply. Both these crops give heavy yields of underground tubers which are rich in starch. Sweet potato vine cuttings and tapioca setts were procured and supplied to the cultivators in large numbers all over the State free of cost and they were encouraged to cultivate these crops. The cultivation of these crops has developed extensively in areas favourable for their growth. The sweet potato has spread very widely in South Kanara and the tubers are made available in the local market all through the year. It is reported to be used as a staple food for one meal a day by the poor people. Tapioca has spread well in Salem district and factories producing sago, tapioca flour and tapioca-semolina have developed.

As a result of the importance of sweet potato as a potential subsidiary crop for the future, local varieties and varieties imported from America by the Sri Vivekananda Laboratory, Almora, were secured and trials on their yield have been taken on hand in some of the Agricultural Research Stations. It is usually propagated by planting stem cuttings and chances for large variations occurring by such vegetative propagation are not so great as in the case of crops propagated by seeds. A few crosses have been artificially made between freely flowering varieties and some hybrids have been produced at Coimbatore and their performances are being observed.

Travancore and Cochin are cultivating a large number of indigenous and exotic varieties of tapioca; planting materials of some promising varieties have been secured and are under trial here.

Onions.—(Plate 66.) This is one of the few vegetables that combine the value of a condiment also. There are two distinct types the indigenous variety with a number of small cloves forming the bulb and the '*Bombay*' or '*Dhulia*' onion which has a big single bulb. The indigenous type is propagated by splitting the cloves and planting them in the field. The *Dhulia* type is propagated by seeds. The production of improved strains was undertaken at the Agricultural Research Station, Hagari, in 1933. Five improved selections were singled out in 1940 and carried forward. Further work could not be continued for want of adequate area in the station.

Onions are often badly damaged by the attack of thrips. Fish oil soap, nicotine sulphate and tobacco decoction sprays formed the routine treatment for thrips attack. D.D.T. and Gammexane dusting has now become the routine control measure for thrips, and is extremely effective.

Exotic vegetables.—Exotic vegetables are grown in the hill stations generally and occasionally at the foot of the hills in the plains. The Nilgiri and Kodaikanal hills and Bangalore have been

supplying most of the vegetables that are being distributed to the various towns in the State. The demand for exotic vegetables was increased during the war for supply to the military and special schemes were run at Coimbatore, Hosur, Kodaikanal and the Nilgiris successfully and large quantities of vegetables were produced. The exotic vegetables do not set seed properly in this country and efforts were made locally at the Agricultural Research Stations in the Nilgiris to produce seeds. Seed production was shown to be possible, but the seeds were not equal to the imported seeds in quality.

The indigenous vegetables.—The indigenous vegetables are being grown in all the Agricultural Research Stations mainly for the production of seed. The seeds are distributed to the various agricultural depots for being made into small packets for sale to the general public.

Large vegetable farms were run either by the department or under the departmental supervision during the war years for supply of vegetables to the army, at Salem, Buchireddipalem, Nagari, Coimbatore, Poonamallee, Visakhapatnam, Ettarai, Mangadu and Hiranyamangalam. The growing of vegetables was undertaken gladly by the cultivators as the military authorities arranged to purchase all the vegetables at pre-arranged fixed rates and there was an assured market. The cultivators do not normally grow vegetables on a field scale, as there is not any assured market for the produce and as vegetables have to be wasted during periods of glut in the market.

The various vegetable schemes showed clearly that though vegetables could be grown all through the year, they do well in particular seasons. The sowings done in March and August do extremely well, bear profusely and better than sowings done in other periods of the year. The vegetables sown in the other months of the year do not grow vigorously and the yields are low, but this is compensated by the higher prices got for the produce during the off-seasons.

Planting the vegetables on the ridges was found to be more convenient and advantageous than planting in beds. The ridge planting facilitated clean cultivation, top dressing of manures to force the growth of vegetables, and ease and saving in irrigation.

The nursery area required for raising vegetable nurseries had in most cases to be one-fortieth of the area proposed for planting. Raising the nursery beds over the ground level was found to be advantageous for draining the excess water from the nursery beds during rainy periods. This helped to produce vigorous and healthy seedlings.

It was also seen that in vegetable plants, picking the fruits in the early stages always tended to prolong the bearing period. Allowing even a few fruits to mature and dry on the plant discouraged the formation of further flower buds and production of

fruits. The production of seed completes the life cycle in the plant organism and the natural life impulse to produce flowers and seeds to perpetuate the species is lost after seeds are produced on the plant. It would, therefore, be advantageous for vegetable producers to be periodically and frequently gathering the young vegetables in their prime, to prolong the fruit bearing phase of the plant.

Vegetable seed supply in Madras City.—A small departmental staff is maintained at Madras for introducing vegetable gardening in the compounds of houses in the City. A seed store is maintained at Mount Road for supply of vegetable seeds, fertilizers and chemicals required for treating plant diseases and combating pests. The staff supply vegetable seeds, seedlings of trees grown for shade and fuel, and chemicals used for combating pests and diseases and give technical advice and help for home gardeners. This service is very much appreciated and the area under vegetables is estimated to have reached 1,500 acres in 1950, from about 500 acres in 1944, when the service was first started. The tempo given by the staff for the "Grow More Vegetables" plan is being maintained and augmented by the assistance offered by voluntary service of the organizations like the Agri-Horticultural Society, the Y.M.C.A., the Guild of Service, the Avvai Home and similar bodies.

CHAPTER 10.

SUGARCANE.

(Botanical name —Saccharum officinarum.)

Telugu—*Cheruku*, Tamil—*Karumbu*, Kannada—*Kabbu*, Malayalam—*Karimbu*, Hindustani—*Ganna*.

Importance, area, cultivation practices—Manurial experiments at Research Stations, Anakapalle, Gudiyattam, Samalkota, Palur —Varieties—Sugarcane—Sorghum hybrids—Irrigation experiments—Other agronomic trials and improvements—Harvest—Determination of ripeness—Maturity trials at Research Stations —Arrowing—Ratooning and ratoon experiments—Extraction of juice, milling trials, preparation of jaggery—Boiling furnaces—Improvement—The Sindewahi furnace—Boiling process—Jaggery-making trials—Quality characteristics of jaggery—Cream jaggery—Sugar manufacture by the open pan system—Sugarcane products—Sugar Industry and protection—Sugar excise fund—Legislation controling manufacture and movement of jaggery—The Indian Central Sugarcane Committee —Research on sugarcane—Acreage under improved varieties and average yield per acre.

Introduction.—India may be said to be the home of sugarcane, from where it spread to other countries of the East and the West. The cultivation of the crop could be traced to the early Vedic period. Mention was made about sugarcane in the ancient sacred works and medical books. From time immemorial, the crop was raised in India for the production of " Jaggery " and sugarcandy. Production of white sugar is of recent origin and dates back to the second decade of the nineteenth century.

Sugarcane is one of the most important commercial crops of Madras State. With the spread of civilization in India, sugar is fast replacing " Jaggery " and to keep pace with the increasing demand for sugar, the Indian Sugar Industry is also developing progressively. During the decennium 1930–40, the Indian Sugar Industry made rapid progress. The number of sugar factories in Madras State during this period increased from two to eleven and in India from 32 to 134. The progress thereafter was rather slow, though there is still scope and necessity for rapid expansion in the interests of the country.

Sugarcane is under cultivation in Madras State in all the districts to some extent or other, except the Nilgiris. The important sugarcane growing districts are Visakhapatnam, East and West Godavari, Krishna, Bellary, South Arcot, North Arcot, Chittoor, Salem, Coimbatore, Tiruchirappalli and Madurai. Mention need be made in this connection about the sugar factories at Nellikuppam in South Arcot district and at Samalkota in East Godavari district. The former was established long ago and was

responsible to a large extent for the expansion of sugarcane cultivation in South Arcot district, while the latter has in a large measure helped to expand palmyra jaggery-making as a cottage industry in Godavari district.

Sugarcane is utilized for the following purposes in the order of importance: (1) jaggery or gur; (2) sugar; (3) seed for planting and (4) chewing.

Importance of sugarcane.—Sugarcane is one of the most important money crops that play a vital role in the economy of the cultivator, in Madras State. It covers about 1·1 per cent of total area under cultivation in this country and 0·46 per cent in Madras State. It is at present cultivated over two lakhs of acres in Madras. Madras State on an average produces 450,000 tons of jaggery and about 50,000 tons of sugar. In 1950–51 season, the production of sugar was over 89,000 tons. It exports jaggery mainly to Orissa, Hyderabad, Bombay, Madhya Pradesh and of late to Ceylon also. The import of sugar is mainly from the surplus States of Uttar Pradesh and Bihar. The per capita consumption of sugar is low in Madras State being only 4·1 lb. compared to 7·0 lb. for All-India. Considering the ideal environmental conditions of this State for sugarcane, the average yields per acre are low, and higher yields can be obtained, provided adequate facilities regarding irrigation and manuring are given.

Cultivation practices—Climate.—Sugarcane is a tropical crop. But it extends much farther beyond these zones. The sugarcane as normally cultivated is of about 10-12 months duration. Warmth and humidity during the growing stage and dry chilly weather at maturity are ideal for the crop. In South India sugarcane is growing under rainfall conditions ranging from about 20 inches to 100 inches or more. But, it is in the tracts of moderate rainfall of 30 inches to 40 inches supplemented by sufficient and timely irrigation that the crop thrives best. Excepting the hill stations in the rest of the State, both coastal and inland, the temperature variations range from the minimum of 55 F. during the period December to February, to the maximum of 112° F. in the months of May-June. During the rest of the period the mean temperature ranges from about 75 to 90° F. The average humidity over a wide area in this State ranges from 75 to 85 per cent. Thus the mean temperature variation and average humidity prevailing in Madras State are very congenial for the growth of sugarcane. Well-distributed rainfall throughout the growth period of the crop, absence of strong winds and stormy weather in the north-east monsoon, viz., October to December, and prevalance of normal temperature and humidity conditions are always advantageous, in giving the best crops.

Soils and rotation of crops—Soils.—Sugarcane is a long duration exhaustive crop. It thrives best in fertile soils with good drainage facilities. The crop is practically cultivated on a variety

of soils, namely, clay soils, clay loams, red loams and sandy loams. With proper manuring and attention, good crops are being grown in all the soil types mentioned above, in the various localities in the State. Shallow soils, and poor gravelly and sandy soils are unsuitable and hence not used for the cultivation of sugarcane. Low-lying lands subject to submersion and ill-drained lands prone to water-logged conditions during rainy seasons, are also to be avoided as these unfavourable conditions are detrimental to the growth of sugarcane.

Rotations.—In wet lands sugarcane is rotated with rice leaving an interval of at least two years, e.g.—

First year—Sugarcane plant crop.
Second year—Sugarcane ratoon.
Third and fourth year—Rice followed by plus or fodder.
Fifth and sixth year—Again sugarcane and ratoon.

If land is available, it is desirable to extend the interval even up to three or four years to safeguard the soil against depletion.

In garden lands, sugarcane is rotated with other garden crops—

First year—Sugarcane.
Second year—Ratoon.
Third and fourth year—Maize, ragi, sorghum, vegetables, fodder and green manure crops.

Preparatory tillage.—Sugarcane is cultivated in wet lands in rotation with rice, and in garden lands in rotation with other irrigated crops. Soon after the harvest of the previous crop, tillage is commenced. The land is ploughed a number of times, fairly deep, till the required tilth is obtained. For ploughing, both the wooden and iron ploughs are in general use. In case of wooden ploughs, the heavier types intended for dry land ploughing are better suited for the purpose. Wherever iron ploughs are in use they are preferred for this specific purpose. The main planting season is March–April, but in some parts it commences from the middle of January. Hence, in wet lands, a short duration crop of rice is chosen to precede the sugarcane crop so that there may be enough time for the preparatory tillage after the harvest of rice by about the end of October or early November. Sufficient gap between the harvest of rice and planting of sugarcane is necessary for the preparation of the land and manuring. In clay soils, due to the stiffness of the soils more number of ploughings and more time are necessary to bring the land to proper tilth. In garden lands, the preparation is much easier due to the comparatively loose nature of the soils, and, the preceding crop can also be conveniently chosen. Under such irrigated or garden land conditions, there is scope for raising a suitable green manure crop for sugarcane. Neither too deep ploughing nor too fine tilth is necessary. It is enough if good tilth is attempted to a depth of about 9 inches, and the soil allowed to weather so that when irrigated, prior to planting, there are no clods in the field. Depending upon

the nature of the soils and the previous crop, the number of ploughings may vary from four to eight and the optimum may be about six. At the Agricultural Research Station, Samalkota, ploughing was found to be as good as crow-barring, a local practice in early years in preparing the land for sugarcane.

Manuring.—Sugarcane is heavily manured. Bulky as well as concentrated manures are applied.

Basal dressing.—Cattle manure is the common basal dressing (applied before planting) given. After two or three ploughings the manure is applied to the land. The quantity used varies from ten carts (or about five tons) to about 30 carts (or 15 tons) per acre. About ten tons is the usual dose. Sugarcane is cultivated as a cash crop with great care and attention and hence the cane growers attempt to apply sufficient manure to the crop. When cattle manure is not available, sheep-penning is also adopted. Penning about 2,000 to 3,000 sheep per acre may be considered as the usual practice. Wherever possible sheep-penning substitutes or supplements cattle manure, depending upon the availability of both in the locality. Wherever composts are available, it replaces cattle manure.

Green manuring.—The practice of green manuring is beneficial to sugarcane. It can be conveniently practised by choosing a suitable green manure crop like sunnhemp, to precede sugarcane. It is possible to sow sunnhemp just before the harvest of rice, if it is a short duration crop. It can be incorporated into the soil after a month's growth. But, due to various practical difficulties, this practice of green manuring is not largely adopted, though it is recognized as good by the ryots everywhere. Growing of green manure crops either previous to sugarcane or in between cane rows where possible would reduce the cost of manuring. In 1950-51 season, nearly 5,000 acres of sugarcane were inter-cropped with green manure.

Green leaf manuring cann lso be adopted wherever sufficient green leaf is procurable cheaply. This practice is extensively followed in Chittoor district, where " pungam leaf " is applied to sugarcane crop both as basal and top dressings. Similar practices also existed in parts of Visakhapatnam district where wild indigo leaf was largely available from waste lands. This is a practice worth adopting whenever conditions permit and facilities exist.

Top-dressing.—It is not enough if all the manurial requirements of sugarcane crop are applied in the form of cattle manure, compost, sheep manure or green manure, as basal dressings. To supply the full plant-food requirements of the crop in a convenient, cheap and in an easily available form, application of oil-cakes and nitrogenous fertilizers either alone or in suitable combinations, is the general practice now, all over. The oil-cakes used are groundnut oil-cake, castor oil-cake, pungam oil-cake, neem oil-cake, coconut oil-cake and tobacco oil-cake, in the order of importance. The choice of one or

Plate 67.—Top dressing sugarcane.

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the other depends upon the availability and prices apart from the nitrogen content of the manures. The fertilizer commonly used for cane is sulphate of ammonia. The method of application is by a combination of these two manures (oil-cakes and sulphate of ammonia in the ratio of 1 :1 or 2 :1 on nitrogen basis). Cakes are powdered and mixed with the fertilizers. The total quantity of manure to be applied is split up into two equal doses and the first dose is applied, 40–45 days after planting and the second is applied when the crop is three to five months old. But when irrigation facilities do not permit such application of manure in two doses, it is applied in one dose in the second or third month, when sufficient water is available to irrigate the cane crop. The application of the second dose often synchronises with the earthing up of the crop with the onset of rains in June–July. A quick growing green manure crop like sunnhemp can be sown along-side the sugarcane rows when the crop is about two months old, so that inter-culture may not be impeded and initial growth of sugarcane is not in any way affected. At the time of earthing up, the green manure plants are pulled out, spread along the bases of the clumps in the row and covered over to serve as green manure. Instead of sunnhemp, any other crop like "Pillipesara" or cowpea, can be sown, even in the inter-spaces to serve also as cover crops in summer. In such cases the inter-spaces are thoroughly weeded and hoed once before sowing these crops. This practice is being adopted in certain tracts, green manure crops with erect growing habit like sunnhemp or daincha being preferable to spreading types.

Manurial experiments on sugarcane.—Manurial experiments were conducted during the past four decades on sugarcane, primarily in the research stations at Anakapalle in Visakhapatnam district, Gudiyattam in North Arcot district, Samalkota in East Godavari district and Palur in South Arcot district.

Anakapalle—Trials to test the effect of manuring the nurseries.—Seed crop used for setts indicated that increased manuring to the nursery crop did not show any advantage. The nursery crops were manured at 25, 50, 75 and 100 lb. nitrogen per acre and planted out in the main field uniformly manured. The results disclosed that the general effect of nursery manuring was not significant.

In an experiment where spacings and manurial doses were tested, in two out of three years, the general effect of spacing alone (4 links between rows) was significant but not the manurial doses nor interactions between spacings and manures. The spacings tried were 3 × 5 (i.e., three links between rows on the bed and five links between rows on the trench side) 4 × 4, and 4 × 6 links, trenches alternated with beds. The dosages of manure tried were 25, 50, 75 and 100 lb. nitrogen per acre.

Molasses tried as manure gave lower yields than sulphate of ammonia, "Pillipesara" green leaf, or groundnut cake on equal nitrogen basis (26 lb. nitrogen per acre). Between 26, 52, 78 lb. nitrogen per acre applied as molasses, there was no significant difference in yield between them.

To study the effect of phosphatic manures on the quality of the juice, an experiment was laid out with two treatments treated and not treated—the treated receiving 112 lb. of super phosphate over a basal dressing of five tons cattle manure and 100 lb. nitrogen per acre, while "not treated" received only five tons cattle manure as basal dressing and 100 lb. nitrogen per acre. The results indicated that there was not much difference in yield or in the quality of the juice between the two treatments.

An experiment was laid out to determine the optimum dose of manure for sugarcane with two major treatments, (1) basal dressing of 10 tons cattle manure per acre and (2) no basal dressing, and six minor treatments: 0, 50, 100, 150, 200 and 250 lb. nitrogen per acre applied in the form of groundnut-oil cake applied in two equal doses—one at planting time and the other at the time of earthing up. The results indicated that 100 lb. nitrogen per acre is about the optimum dose for sugarcane in the locality.

To find out the effect of concentrated nitrogenous manures on the germination of sugarcane an experiment was conducted with 50 lb. nitrogen as groundnut-oil cake, 50 lb. nitrogen as sulphate of ammonia and 50 lb. nitrogen (2/3rd as cake and 1/3rd as sulphate of ammonia) compared with no manure. The manures were applied at the time of planting and the results indicated that the application of nitrogenous manures had no effect on germination.

The manurial value of "salvaged" ammonium nitrate was tested. The nitrate plots recorded the lowest yields and the results indicated that there was nothing to recommend in the salvaged ammonium nitrate as manure for sugarcane in preference to other nitrogenous manure already in use.

An experiment to study the optimum time of application of manure was conducted with four treatments, viz., 150 lb. nitrogen (two-thirds as groundnut cake and one-third as sulphate of ammonia) (i) all applied at the time of planting in one dose, (ii) all applied in one dose two months after the planting, (iii) all applied in one dose four months after planting and (iv) applied in two equal doses, half at planting time and half at the time of earthing up. The results indicated that it is better to apply all the manure two months after planting or half at the time of planting and the other half at the time of earthing up, than applying the manure in full at the time of planting or four months after planting.

Gudiyattam—Importance of manuring the main field.—In order to find out if the seed material from an intensively fertilized nursery crop (seed crop) can come up well with less manure in

the main field, so that there may be economy in expenditure under manure, a trial was conducted with J. 247 (247 B). The results showed that though the setts planted from an intensively fertilized nursery crop were better in germination and early vigour, the ultimate yield depended chiefly upon manuring the main field. Manuring the nursery crop heavily, and reducing the dose of manure in the main field was not of much avail.

Optimum dose of manure for sugarcane.—Six levels of nitrogen viz., 0, 50, 100, 150, 200 and 250 lb. nitrogen per acre as groundnut oil-cake over a basal dressing of 10 tons of cattle manure per acre with Co. 419 variety, were tried. There was good response to nitrogenous manuring up to 200 lb. nitrogen per acre. The yields of plot which did not receive any oil cake, were miserably poor though the plots had received cattle manure as basal dressing. Sugarcane requires adequate concentrated nitrogenous manure like oil cakes up to 200 lb. nitrogen per acre to give optimum yields in this tract.

Effect of application of superphosphate.—Application of superphoshate at one cwt. per acre did not have any beneficial effect on the quality of the juice of cane.

Effect of manuring on germination of sugarcane.—To study the effect of concentrated manures on the germination of sugarcane when applied at the time of planting, 50 lb. nitrogen as castor oil cake or sulphate of ammonia or a mixture of both in the proportion two-third as castor cake and one-third as sulphate of ammonia, was applied, the variety being Co. 119. The results of three year trials indicated that application of the above dose of concertrated manures at the time of planting did not have any adverse effect on the germination of cane.

All the varieties under observation plots at Anakapalle and Gudiyattam were raised under two levels of irrigation and manure, namely " normal " and " restricted ". Under the treatment " normal crops " received 100 lb. nitrogen per acre and irrigations once a fortnight, while under the other treatment, " restricted crops " received 50 lb. nitrogen with half the number of irrigations given to the normal. The trials at Anakapalle indicated the fact that the restricted treatment while reducing the tonnage of cane per acre, improved the juice quality in all the varieties by inducing earlier maturity and higher sucrose content and purity. The results at Gudiyattam indicated reduction in both yield and sucrose content.

Samalkota.—Manurial experiment with sulphate of ammonia in comparison with castor-oil cake and groundnut-oil cake was conducted. There was no difference between the different manures as long as they were applied on equal nitrogen basis.

Graded doses of nitrogen, 50, 100, 150 and 200 lb. nitrogen per acre as groundnut cake and sulphate of ammonia in the ratio of 1 : 1 tried, indicated that higher tonnages were recorded with

increased doses, but differences between 150 and 200 N and 100 and 150 N were not statistically significant. All higher doses were superior to 50 N. The highest dose of 200 N gave the maximum yield. However, 150 lb. N dose was found to be an economical one. Higher doses also resulted in delay in maturity.

Time of application of manures.—Application of (i) 100 lb. Nitrogen in one dose at planting time, (ii) 50 lb. N at planting time and 50 lb. N in June, (iii) 30 lb. N at planting time, 40 lb. N in June and 30 lb. N two months after the second dose, were tried on Co. 419. Application in two doses, half at the time of planting and half at the time of earthing up in June, was found to be economical.

Effect of combinations of phosphatic manures with graded doses of nitrogenous manures with Co. 419 variety.—The doses under trial were N, 2 N, N + P, 2 N + P, 3 N + P, N + 2 P, 2 N + 2 P and 3 N + 2 P. The phosphate combination had no effect on yield and hence was found to be uneconomical.

Palur.—Comparison of the effect of organic and inorganic nitrogen alone and in combination was made. The different manurial doses tried were, (i) no manure, (ii) 75 lb. N as sulphate of ammonia, (iii) 150 lb. N as sulphate of ammonia, (iv) 75 lb. N as groundnut oil-cake, (v) 150 lb. N as groundnut oil-cake, (vi) 75 lb. N half as groundnut oil-cake and half as sulphate of ammonia. 150 lb. N half as groundnut cake and half as sulphate of ammonia was found to be the best.

A combined manurial and varietal trial was conducted with the following manures :—

(i) N—O, 75, and 150 lb. per acre.

(ii) P_2O_5—35 and 70 lb. per acre.

(iii) K_2O—O, 50 and 100 lb. per acre and varieties Co. 419, Co. 349 and POJ. 2878.

The following results were recorded :—

(*a*) Co. 419 with 75 N gave as good yields as Co. 349 with 150 N.

(*b*) Co. 419 is capable of thriving even with less doses of N.

(*c*) Higher doses of N have not affected the sucrose content.

(*d*) P_2O_5 and K_2O either alone or in combination have not influenced the yield or quality of cane.

The experiment to determine the *optimum nitrogen* dose for sugarcane as groundnut oil-cake, with and without cattle manure and its effect on quality of jaggery indicated that—

(*a*) No significant differences were noticed between yields from ' cattle manure ' series and ' no cattle manure ' series in any of the seasons in respect of both the varieties tested.

(*b*) There was regular increase in the tonnage of cane with increase in N level, with a substantial increase with the maximum dose of N at 250 lb. per acre.

(c) In respect of both the varieties tried, there was no difference in quality of juice by the application of cattle manure. The highest sucrose content and purity were obtained in the plots manured with 100 lb. N. The higher doses of N reduced very slightly the sucrose content in the juice and its coefficient of purity.

(d) When the economics of manurial treatments were considered, it was observed that with the increase in the dose of N up to 250 lb. N there was increased net income.

(e) As a substantial increase in the yield of cane occurred even at the highest dose of nitrogen, viz., 250 lb. N per acre, the point at which further addition of N does not result in increased yields could not be determined in this trial.

Review of all the manurial experiments conducted in the State Agricultural Research Stations.—All the manurial experiments conducted in the various Research Stations were reviewed and the summary of conclusions drawn from the experiments are as follows :—

(i) It has been definitely established that the application of nitrogenous manures increases considerably the tonnage of the popular varieties of sugarcanes tested.

(ii) Phosphates, when applied to sugarcane, did not influence either the quality of juice or yield of cane.

(iii) Sulphate of ammonia alone or in combination with oil-cakes, was definitely superior to oil-cakes alone used as manures.

(iv) Increased doses of nitrogen gave significantly higher yields up to the level of 100 lb. to 250 lb. per acre depending upon the tract and initial soil fertility.

(v) Application of groundnut cake and sulphate of ammonia in the proportion varying from 2 : 1 to 3 : 2 ratio was found to be efficient. The following doses of nitrogen are optimum for normal yields in the tracts mentioned below :—

Anakapalle ...	100 lb. N per acre.
Samalkota ...	150 lb. N per acre.
Gudiyattam ...	200 lb. N per acre.
Palur	250 lb. N per acre.

(vi) Application of manure in two doses, one 40–45 days after planting and the second at the time of earthing up is advantageous.

(vii) The intensively fertilised seed material has responded more favourably to all doses of nitrogen than poorly fertilised seed material.

(viii) Though the inorganic fertilisers contribute to the increase in tonnage, these are not effective in improving the quality of juice when applied in large doses. A basal dressing of cattle manure is to be recommended, not so much for its nitrogen content as for its effect on the soil.

(ix) Increasing doses of nitrogen increases tonnage of sugarcane per acre, but beyond an optimum level it delays maturity and depresses sucrose content also. The optimum dose, therefore, is one that gives increased yield per acre without delaying maturity or depressing sucrose content.

(x) Under normal cultural practices, there is no significant increase in tonnage of sugarcane beyond the dosages 100 lb. N and 150 lb. N in Anakapalle and Samalkota, respectively.

At Gudiyattam there is evidence for increase in tonnage of cane up to 200 lb. N.

At Palur there is appreciable increase in tonnage of cane even up to 250 N and there may be response even to larger doses.

The delay in maturity and depression in sucrose starts at about 150 lb. N level at Anakapalle, and Samalkota, and at 250 lb. nitrogen or more at Gudiyattam and Palur.

Planting--Layout of the field.—Before planting, the land is levelled and laid out into ridges and furrows at distances of about 2½ to 3 feet. This has become at present almost a general practice.

At the Agricultural Research Station, Samalkota, an experiment was laid out to compare the effect of deep trench planting (12 inches deep) against bed planting (surface or shallow) to find out whether it would in any way prevent the usual lodging of the crop in the later stages and also reduce the cost of wrapping and propping. The results were erratic with indications of less lodging in the trench planting in some seasons. Germination in trench planting was also affected in some seasons.

Planting in furrows is found to be a very satisfactory method. It facilitates the usual operations of planting, manuring, interculture, irrigation and drainage. Planting in this system should be neither deep nor shallow. The germination is then satisfactory. For these reasons, this system is becoming more popular.

Spacing.—The spacing between furrows is about 2½ to 3 feet, depending upon the nature and fertility of the soil and the variety planted. Spacing experiments at Anakapalle and Samalkota indicated that four links or 2 feet 8 inches was the optimum spacing. Accordingly in pactice also 2½ feet to 3 feet spacing is being adopted by cultivators.

Choice of seed material.—It is a recognized fact that the buds of immature sugarcanes germinate well. The buds of the tops of cane germinate well. Ryots prefer to utilize the immature top portions of cane as seed material; failing this, the next choice is for mature canes. Planting setts taken from the whole cane is sometimes done but it is an undesirable practice which results in low germination and high seed rate. There is a practice of raising sugarcane crops entirely for the purpose of seed material. These crops are planted in about June to August and used for seed

Plate 68.—Planting Sugarcane in furrows.

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material in February-March. All the setts from such young crops (short crops) germinate very well. This practice is followed in parts of Salem and Tiruchirappalli and Krishna districts. Where such special crops exist there is no need for the harvest of the previous season's crop and planting of the succeeding crop to synchronise. They can be taken up independent of each other. Such crops raised specially for seed material are now known as "short crops" or "seed crops."

Short crop.—Small areas are chosen preferably by the side of the proposed sugarcane area, well-manured and planted in August-September. This crop would be about six months old by February-March. Short crops would provide material sufficient for eight to ten times the area. These are useful where the harvest of the previous crop and the planting of the next do not synchronise. Germination would be better and hence less seed material need be used.

Experiments with short crop seed material.—An experiment was laid out at Anakapalle in the years 1924–28 with the variety J 247, to find out the efficacy of short crop seed material over mature seed material. The results of this experiment indicated that short crop seed material when planted yielded on an average 17·5 per cent more than the crop planted with mature seed material.

Preservation of seed material.—Under normal conditions, there is no need to preserve seed material. The land is prepared and laid out. The canes for a standing crop are cut just before planting. It is also common experience that the seed material should be as fresh as possible for best germination. However, necessity may arise to preserve the seed material for varying periods when it has to be transported over long distance, when it has to be imported by train from distant places, and when planting has to be delayed on account of unforeseen circumstances. In such cases, there is need to carefully preserve the seed material. In this State, the usual method adopted is to heap the canes under shade and cover it over with trash. The canes are stripped and cut into setts just before planting.

Experiments to find out the best method of preserving the sugarcane seed material were conducted at Anakapalle with the following treatments using Co. 419 :—

(i) Setts heaped together and covered with trash and kept moist for periods of 15, 30 and 45 days (Heap method).

(ii) Pitting whole canes with trash and preserving for 15, 30 and 45 days (North-West Frontier method).

(iii) Bundles of setts planted erect in a puddle, covered with paddy straw and kept moist by watering frequently (Kurnool method).

(iv) Short crop seed material—cut fresh (control).

The results indicated that planting short crop seed material gave the maximum yield. Next come the Heap, Kurnool, and North-West Frontier methods in the descending order of yields. It is therefore advantageous to plant short crop seed material fresh and in case of necessity preservation by the heap method, for not more than fifteen days may be done.

Seed rate.—Sugarcanes intended for seed material are hand-stripped of trash or dry leaves without damage to the buds. The canes are cut into bits, each bit containing three buds. One to two inches of internode are left on either ends of the bit. The bits so cut are called setts. In the beginning when Coimbatore seedlings had not spread, usually a heavy seed rate ranging from 30,000 to 40,000 setts per acre, was used for planting as the varieties under cultivation had low germination capacities. With the advent of Coimbatore seedlings which are capable of giving fairly high germination percentage (over 60 per cent), the seed rate has been considerably reduced.

Seed rate experiments.—Experiments conducted at Anakapalle with J247 and Co.419 with seed rates 12,000, 16,000, 20,000 and 24,000 setts per acre, indicated that there was not much difference in yields between the different seed rates. Hence 12,000 to 16,000 setts per acre were found sufficient for that locality. Similar experiments at Palur also indicated that 12,000 to 16,000 setts per acre should be sufficient with good seed material. At present seed rate of about 16,000 setts per acre is generally adopted with the popular Coimbatore canes.

From the experiments conducted at Anakapalle and Samalkota, to compare the method of planting seedlings aged 2, 3, 4 and 5 weeks old with the method of planting setts, it was concluded that good crops could be obtained by using seedlings not more than four weeks old. This method is not in general practice as it entails extra expenditure in raising seedlings in a nursery with no special advantage over planting setts.

When sugarcane setts are planted, the first sprouting of buds is seen at the end of ten days after planting. Within the first two weeks, 35 per cent of the buds germinate. Between the second and third weeks 40 to 48 per cent of the sprouts come up and the germination is complete by the fifth week. Hence it is necessary to keep the soil in proper moisture condition during the period to ensure good germination. Setts should not be planted deep; only half an inch of soil may cover the setts. Irrigation during germination must be properly controlled depending upon the nature of the soil, so that there may be optimum moisture. The soil must be kept in a friable condition by timely hoeings.

Time of planting.—Sugarcane planting commences in January and continues up to May in the different tracts of this State. March can be reckoned as the main planting time over a large

area. Time of planting mainly depends upon the rainfall distribution, the source of irrigation water, the rotation crops, the nature of the land and the requirements of the sugar factory in factory areas. Early planting in January-February is resorted to in delta tracts where the irrigation is from canals. The canals will be closed in May during which period there is no facility for irrigation of the crop. By planting early, the crop puts forth sufficient initial growth before May which enables it to withstand the absence of irrigation and severe summer. Under lift-irrigated conditions, where water supply is always assured, plantings are usually done in March-April. Late plantings in May are adopted when the land is occupied by another crop till March-April; and in certain localities where continuous supplies of irrigation water may be available from May onwards the crop is planted in May. January to May is the main and only planting season in Circars, Ceded districts, Carnatics and many of the Southern and Central districts. But in Coimbatore, Tiruchirappalli, and Salem tracts there is also a practice of planting cane in July-August. If the crop can be planted in more than one season, it is a decided advantage for the sugar industry as it leads to a long crushing period, and for the jaggery making industry as it gives jaggery in lean months benefitting the cultivators and labourers as well.

Time of planting trials.—With the object of finding out the best time for planting and to investigate into the possibility of planting cane in more than one season, monthwar planting trials were conducted for a number of years at Anakapalle, Samalkota, Gudiyattam and Palur. During the first two years of trial, it was decidedly noted that September to December plantings were uneconomical and undesirable, as the growth was poor. Consequently the experiment was altered to compare the performance of outstanding varieties from January to June plantings. The results at Anakapalle indicated that best results could be obtained by planting from March to May. At Samalkota, January–March months were the maximum yields and planting before January and late after April proved unsuitable. At Gudiyattam, May planting recorded highest yield in Co. 419; but April crop had the highest sucrose content of 18 per cent followed by March, May and June plantings.

Varieties.—Sugarcane varieties differ very widely in their morphological, physiological and economic characters, viz., colour, thickness, length and shape of internodes, number of internodes, rind hardness, growth and habit, flowering, tillering and capacity to withstand drought and water logging, resistance to pests and diseases, richness of juice and time of maturity. Identification of varieties is based on the variations in the following characters, general habit, stalk, internode, node, growth ring, root band, leaf scar, glaucous band, buds, leaf-sheath, throat, collar, ligule, ligular processes, leaf-blade, arrow and inflorescence.

Sugarcane varieties under cultivation in this State may be mentioned under the three categories; namely, (1) indigenous, (2) exotic, and (3) Coimbatore seedling canes.

Indigenous varieties at present occupy only a little area in remote places and are almost getting extinct. Due to inherent defects such as susceptibility to pests and diseases, necessity for maintaining ideal conditions of cultivation necessitated their replacement with more suitable varieties. These were however very sweet and rich in juice and soft rinded. They are medium to thick in girth, "*Thellacheruku*", "*Peddacheruku*", "*Chinnacheruku*", "*Bontha*", "*Desavali*", "*Keli*", *etc.*, in Telugu districts, "*Poovan*", "*Vellai*" and "*Nanal*" in Tamil districts, "*Hotte*" and "*Javari*" in Bellary area were some of the popular indigenous types. The same variety was also called by different names in different localities. They were all cultivated till about the nineties of the last century. When "Red Rot" a devastating fungus disease which almost brought the cultivation of sugarcane to the point of extinction in Godavari district broke out, the problem of sugarcane improvement was taken up. Experts in the line suggested the importation of important varieties from other countries.

Exotic types, viz., purple Mauritius, striped Mauritius, red Mauritius, Java Hebbal, B. 208, J. 207, POJ. 2878, Fiji B, etc., were imported from other countries at different times for trial in the State and many of them proved successful to tide over the crisis. All these varieties are thick canes with soft rind, and fairly rich in juice with high purity but many of them demand fertile soil and careful cultivation. At this stage the Imperial Sugarcane Breeding Station at Coimbatore came into existence and took up the work of evolving suitable varieties for the different regions in India.

The Coimbatore varieties are all developed from seeds set by open or cross pollination deliberately planned. After careful study of innumerable hybrids suitable ones were chosen for different tracts and distributed. Credit should be given in this connexion to the late Dr. Barber who first laid the foundation for sugarcane research and evolution of new varieties and then to Sri T. S. Venkataraman (lately Sugarcane Expert) whose untiring work and zeal and mastery over the breeding aspect of sugarcane resulted in bringing about very outstanding Coimbatore varieties which have almost ousted all others from the field all over India. The Coimbatore canes are classified as *thick* and *thin* canes. Thick canes are thick in girth, and generally demand fertile soils, good manuring, irrigation, etc., and are more suitable for the conditions prevailing in Bombay, Madras and South India as a whole. Thin canes are thin in girth, hardy and are capable of thriving even with scanty rainfall and under poor soil conditions, and these are more suitable for North Indian conditions.

Plate 69.—*Sugarcane variety*—*Co.* 419. P. 444

Plate 70.—Sugarcane POJ 2878—*Horizontally propped.*

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Plate 71.—*Sugarcane Co.* 449—*Wrapped and propped as in N. Circars.* **P. 446**

Varietal studies.—Every year the new seedling canes released from the Central Sugarcane Breeding Station, Coimbatore, are sent to the Research Station at Anakapalle, Samalkota, Gudiyattam and Palur where sugarcane improvement is one of the main items of work. Soon after the receipt of the new types, the material is multiplied in the first year and from the next year onwards they are carefully studied in observation plots. From the studies made regarding the germination, vigour, tillering, girth, length, weight, arrowing, maturity and final yield of cane, the promising varieties are again tested under preliminary yield trials. The outstanding varieties are next subjected to comparative yield trials classified into early, mid-season and late varieties with the respective standards. Outstanding varieties from these trials are also subjected to tests under different conditions such as wet and garden land conditions as is done at Palur, and normal and restricted conditions of manure and irrigation as followed at Anakapalle and Gudiyattam. After such careful study for six to seven years under varied conditions, the varieties that come up to the local requirements are further tested in the regional liaison farms, multiplied and released for trials in the cultivated fields.

Sugarcane—Sorghum hybrids.—Seven sorghum-sugarcane hybrids Co. 351, Co. 352, Co. 353, Co. 354, Co. 355, Co. 356 and Co. 357 were under study at Anakapalle, Palur, Maruteru, Aduthurai and Coimbatore from 1932–33 onwards. They could not stand comparison with the popular varieties in yield nor were they found early as expected and therefore they were not taken up for general cultivation.

At present Co. 419 is the most popular variety throughout Madras State. It possesses the remarkable qualities of high germination, vigorous growth, good tillering, capacity to withstand adverse conditions, good ratooning capacity, high tonnage and good quality jaggery. Thus, it is popular in the jaggery making areas and with some sugar factories of the State. The only defects in this cane are its unsuitability for early crushing, brittleness, lodging and breaking and susceptibility to smut. It is appropriately said to be the " wonder cane " of Madras on account of its high yield and adaptability to varying conditions in the State.

Varietal studies at Anakapalle.—Varietal studies at this station showed that Co. 419 is the best of all Co. canes tried, with a maximum yield of 54·77 tons of millable cane per acre, in 1937–40 trials. Among the early varieties chosen, Co. 527 recorded the maximum yield of 4·603 tons of jaggery per acre while the control Co. 313 recorded only 3·472 tons. Co. 527 was released to the districts to replace Co. 313. Among the midseason varieties (Co. 449, Co. 421, Co. 451, Co. 452, Co. 545), Co. 449 was found promising with the maximum yield of 41·57 tons of cane and 5·034 tons of jaggery of good quality. Hence Co. 449 is being recommended for cultivation as midseason cane. Among the late varieties tried (Co. 331, Co. 419, Co. 444, Co. 538, Co. 544), Co. 444 recorded

the average maximum yield of 44·74 tons of millable cane and 4·725 tons of jaggery per acre. Co. 419 was the next best in the trial. The quality of jaggery of Co. 419 was the best and it easily off-sets the slight increase in jaggery noted in favour of Co. 444. Hence Co. 419 is recommended for late crushing.

Gudiyattam.—Among the five outstanding varieties (Co. 408, Co. 419, POJ. 2878, Striped Mauritius, and J. 247) tested, Co. 419 was decidedly the best with 60 tons of cane per acre. Under restricted conditions of cultivation Co. 213, Co. 243, Co. 281, Co. 313 and J. 247 were tried. Co. 213 and Co. 243 were equally good with an average yield of 29 tons of cane per acre. Among the varieties suitable for early season crushing, Co. 421 was found the best with 30·25 tons per acre. In a subsequent trial with another set of varieties with Co. 421 as control, Co. 449 proved to be the best variety with 33·81 tons of cane per acre, and gave 31 per cent higher yield than the standard Co. 421. Hence in factory areas Co. 449 is recommended for cultivation.

Samalkota.—Yield trial at this station indicated that Co. 419 was the outstanding variety. Co. 545, Co. 421, Co. 541, Co. 453 and Co. 527 were also found very promising with desirable qualities.

Palur.—Under Palur conditions also Co. 419 was found suitable for both garden and wet land cultivation.

Irrigation.—Sugarcane is cultivated invariably as an irrigated crop in Madras State. Unfailing water supply is essential throughout the growth period of the crop. The rainfall has to be supplemented by timely irrigations. The sources of irrigation are mainly canals and wells and to some extent tanks. In the case of canal and tank irrigation the crops generally depend upon wells for irrigation during summer. In delta tracts where canals are closed during summer for about a month, the crops remain unirrigated during that period in the absence of wells. Irrigations must be given judiciously, avoiding excessive watering and taking care to irrigate when absolutely necessary with just sufficient water.

Duty of water experiments.—Experiments were conducted at Anakapalle, Samalkota and Palur on water requirements of sugarcane The results indicated that the average requirements would be 71·31 acre-inches of water for sugarcane for an average duration of 349 days. Rainfall during the period also was included in the total requirements.

Restricted (single) irrigation experiments.—Trials were conducted at Anakapalle, Samalkota and Palur to find out the possibility of raising sugarcane with one irrigation at the time of planting. At Anakapalle, under this restricted system of cultivation, Co. 213 recorded over 40 per cent higher yield than J. 247 (247 B) a cane variety that was then under cultivation. These varieties spread easily into cultivation in the Visakhapatnam district. At Samalkota, Co. 213, Co. 421, Co. 419, Co. 349, Co. 444 and Co. 443

were found fairly suitable under restricted irrigation. Co. 421 was the best with 37 tons followed by Co. 213 with 33·4 tons. Co. 419 was outstanding in withstanding drought. Co. 349, Co. 444 and Co. 443 could withstand the single irrigation conditions as also cyclonic weather. At Palur, the results of the experiments showed that the thin canes could better withstand drought than thick canes. The low yields of canes with restricted irrigation were not commensurate with the saving effected in restricting irrigation and hence restricting irrigation was found unprofitable.

After cultivation.—Sugarcane is given the following after-cultivation operations—(1) weeding and hoeing, (2) filling gaps (3) trenching and earthing up, (4) wrapping and propping (in some places), (5) trashing and (6) removal of late shoots.

Weeding and hoeing.—This is the most important operation. Hoeing and weeding are essential operations intended for suppressing weed growth and to keep the surface layer loose to conserve moisture.

About six hoeings and weedings may be necessary altogether. In portions of South Visakhapatnam district where there is scarcity for water in the early stages of crop growth, cane trash is spread over the planted field to cover it and to conserve the available moisture in the soil. In the initial stage, this operation is done with hand hoe using manual labour. The first hoeing and weeding is given when the crop is two weeks old, to break the hard surface crust and to enable the tender shoots to come up easily. As the crop grows, implements are worked with bullock power in the inter-spaces. Cultivators and H.M. Guntaka No. 2, are very useful for this operation. Under efficient management, these implements can be worked with a single bullock using the bullock harness. Planet junior push-hoes of suitable design are also very useful and effective. The intercultivation ceases when the crop puts forth sufficient growth. Later, only prominent weeds are removed once or twice especially along lines.

Filling gaps.—One month after planting, the gaps in the crop, if any, due to failure of germination in the field, have to be filled up. This is very essential to keep sufficient number of plants in the planted area as otherwise the final yield is bound to be affected adversely.

Extra setts are generally planted at the ends of cane rows and the germinated setts are used for filling up gaps in the field. The gaps are also filled with fresh setts cut for this purpose but this method of filling gaps is less efficient than the former. In some tracts like North Visakhapatnam, there is the practice of raising sugarcane nurseries in small areas on the same day that the crop is planted. In the nurseries the setts are closely packed. The seedlings also will be of the same age as the main crop and the gaps are filled with these seedlings.

Trenching and earthing up.—These two operations also go together and are usually taken up before the onset of heavy rains. By that time, the crop will be about three to four months old. Trenches are dug in the centre of alternate interspaces in Circars districts, and in every interspace in the Ceded and Southern districts. The earth so dug is spread on either side to raise the level of the beds. Thus, the beds and trenches alternate with each other. The spreading of the dug-up earth on the bed is called earthing up and is intended to give more strength and foothold to the clumps. The trenches serve the purpose of drainage channels during rains. At convenient distances cross trenches are also dug to drain out the excess water out of the field. The same trenches also serve as channels for irrigation. The application of second dose of manure to the crop is done at this time. The manure is spread along the lines at the bases of clumps and covered up immediately by earthing up and irrigated. In places where drainage is poor in rainy season trenching is intended to create free drainage. In lighter types of soils, where there is free drainage instead of trenching with manual labour in alternate spaces, deep furrows are made in every interspace with a double mould board or ridge plough. In this case, when the furrow is formed, earth is thrown up on either side towards the base of the clumps. Ridge plough is an effective labour saving implement for earthing up. It covers one acre per day for this operation at a cost of about Rs. 3 whereas the same operation with manual labour costs about Rs. 20 at Gudiyattam.

Wrapping and propping.—Wrapping is covering the sugarcane stalk with its own leaves by twisting them in a convenient manner round and round the stem. About six to eight leaves in the crown of the cane are left out and all other bottom leaves are twisted round firmly. This operation is mainly intended to protect the canes from the attack of jackals, rats and other wild animals, etc., and minimise their damage. It also facilitates propping of canes with bamboos. It is popularly believed that by covering the stalk, rooting is minimised, the quality of juice is preserved and the rind does not split easily and thus prevents attack by insect pests such as borers, etc. Wrapping only is done in Srikakulam, Chittoor and Anantapur districts. Wrapping commences when the crop is about four months old and continues up to the ninth or tenth month.

Propping is an operation done to keep the crop erect and to prevent it from lodging due to severe cyclonic winds which are common in the Circars coast during October and November. Wrapping is usually taken up along with propping, so that the leaves themselves can be used for fastening the clumps to the props. Bamboos are used as props and are usable for about three years. This operation is practised in South Visakhapatnam, East and West Godavari districts and certain parts of Chittoor district. This is a very costly operation and increases the cost of production considerably. In spite of that, it is necessary to wrap and prop as otherwise considerable loss often occurs due to lodging of cane.

Wrapping and propping as practised in Godavari and South Visakhapatnam districts give ten to fifteen tons extra yield per acre over crops not so treated and as such the continuance of this practice by ryots is justifiable for obtaining maximum production per acre. However, methods to cheapen the operation require further investigation. Propping and binding canes by stooking is in trial at Gudiyattam and gives promise of successful results.

The Venkataraman Sub-Committee (1950) noted that the yield of cane is put up by ten to fifteen tons by propping with bamboos as practised in the Circars districts. At the same time the Committee easily visualised the various methods by which this process could be cheapened in the future, such as the use of more lasting posts than bamboos and under certain conditions the process could be done with cocking and twisted trash.

Propping by trash twist method was first tested at Gudiyattam Research Station. In this method, the leaves of cane plant are twisted into a rope form and two adjacent rows are brought together and bound up at about four feet level. This method was extensively adopted in Nellikuppam, Gudiyattam and Vuyyur areas and found to be fairly effective with about 40-ton crop. In the Circars districts it is under further test.

With a view to reduce the cost of propping, the department tried two other methods called, (i) horizontal propping and (ii) wire propping. In horizontal propping, vertical bamboo props are fixed at wider distances of about six feet along rows. Bamboos are tied up horizontally to these props at a height of three feet and the canes are either wrapped to these horizontal bamboos or tied up in a convenient manner. By this method, the number of bamboos required as props can be reduced by nearly half. As the crop grows, another two tiers of horizontal bamboos are put up. In this method, when there are severe winds, the whole line falls down like a wall causing further damage to the adjoining rows. To rectify this defect, cross bamboos had to be tied up at regular and convenient distances and even this was not found very effective. This practice does not find favour among the cultivators and is not practised to any extent in the Circars. In *wire propping*, on either end of the sugarcane row which may be about 40–50 feet in length, stout bamboo standards are fixed; to these standards, thin strong wire passed on either side of the cane clumps is tied up. At regular distances of about two feet, the two wires are interlaced to hold the clumps tight in the loops. The first line of wire is fixed at a height of about three feet and usually two more lines are fixed at distances of two feet. This method is also rather costly initially and is not adopted by the cultivators.

Stooking.—In places, where propping with bamboos is in practice, in the advanced stages of the crop when it is likely to lodge, a few adjoining clumps are brought together like a stook and tied up with some cheap fibre or even cane leaves and sometimes a

strong bamboo prop fixed in the centre. In this method only about 1,000 bamboos are required and is intended to prevent lodging and consequent breakage of the cane.

Trashing.—In some tracts the practice is to remove all the dried up lower leaves, as the crop grows. This operation is called trashing. The crop looks very neat and tidy with clean exposed and naked stalks with the green crowns at the top. This is intended to prevent the sprouting of buds and development of nodal roots due to accumulation of rain water in the leaf axils.

Wrapping and propping trials.—A number of experiments were conducted at the Research Station at Anakapalle, Samalkota, Gudiyattam and Palur on wrapping and propping operations. The results are summarised below.

At Anakapalle, an experiment was conducted to compare the normal bamboo propping with wire propping, with the variety J. 247. From the results of the three-year trial (1937–38 to 1939–40) it was concluded that the cost of wire propping was more than propping with bamboos as locally practised. In a similar trial at Samalkota for three years (1923–24 to 1925–26) with J. 247 and purple Mauritius, the local method of propping with bamboos was as good as wire propping if not better. At Gudiyattam a similar trial was conducted to compare wire propping with horizontal propping, for three years (1937–38 to 1939–1940). The results indicated that propping with wire was effective in preventing lodging, but the operation was costly owing to the large amount of labour involved in digging pits, fixing bamboo posts, cost of bamboos and wire, and handling wire, etc., and cost of this operation amounted to Rs. 95 per acre, while wrapping and propping with bamboos by horizontal method amounted to Rs. 60.

At Anakapalle, further trials made with different methods of wrapping and propping to prevent the crop from lodging and to minimise the cost of cultivation indicated that wrapping and propping as practised locally was the best, under both garden and wet land conditions. Similarly, at Gudiyattam with the variety " Tellacheruku " which has a very bad habit of growth, wrapping and propping with bamboos was found necessary and also economical. Stooking canes prevented lodging to some extent. Propping with wire was effective but costly. At samalkota the results proved that the local practice of wrapping and propping though involving additional cost, is economically sound and gives a higher net return per acre.

Removal of late shoots.—From the months of August—September onwards, i.e., six to eight months after planting, all the side shoots that commence sprouting from the bases of cane clumps are removed. The side shoots or tillers usually appear more towards the borders of fields. If they are not removed, they too grow along with the main shoots and thereby inhibit development

Plate 72.—*Sugarcane trashed.* P. 453

Plate 73.—Harvest of sugarcane.

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of the main shoots. At the time of maturity of the main shoots these tillers will be only five to six months old, immature and unfit for harvest.

Harvest—When to harvest sugarcane.—Sugar is the product we value in sugarcane. It is therefore essential that we get the maximum recovery of sugar from cane. The development of sucrose in sugarcane can be compared to a rising sun. It is very low when the crop is young and gradually increases with age, attains the maximum, and then deteriorates. The period when canes attain the maximum sucrose depends on the age, time of planting and variety. In general, it can be said that canes when planted in February–April attain maturity in twelve months. When planted in May and June, canes attain maturity in ten months though the peak sucrose content is lower than in earlier planting. February–March is the best period for the manufacture of jaggery of good quality and for obtaining the maximum recovery. If the harvest is delayed there is loss of about 500 lb. of jaggery per acre for every month's delay. The deterioration or loss in recovery is still more marked if the harvest is delayed beyond April.

Determination of ripeness in sugarcane.—Unlike grain crops it is not easy to determine the ripeness of cane by mere observation. Though the yellowing of leaves gives some indication of the maturity of cane it is not a dependable sign. Extraction of juice and analysing it for total solids, sucrose and glucose in a chemical laboratory periodically is the best method of determining the ripeness of cane, but this is not possible for ordinary cultivators to do so. However, it should be possible for enlightened ryots to determine periodically at least the brix per cent or the total solids in the juice with the Brixometer. This gives fairly a good idea of the maturity of cane. If the brix, per centage in the case of Co. 419 records 19 to 20 or over, it can be crushed.

The ripeness of cane can also be determined by trial jaggery boilings. The maximum recovery of jaggery that can be expected from Co. 419 or Co. 449 is 12 to 13 per cent by weight of cane.

Ripeness trials and relation between arrowing and ripeness.—Ripenese trials were conducted at Anakapalle, Gudiyattam, Samalkota and Palur with the following objects:—(i) To fix up early, mid-season, and late manuring varieties based on the sucrose content; early varieties should contain at least 16 per cent sucrose in November to December with fair purity (85 per cent), midseason varieties 18 per cent sucrose in January to March, with high purity (90 per cent) and late varieties 14 per cent or more sucrose in April to May with fair purity (85 per cent); (ii) to determine the attainment of maximum sucrose content in the popular varieties tested; (iii) to find out at what time best quality jaggery can be obtained; (iv) to study the onset of deterioration in juice in order

to determine the proper time of harvest for different varieties and (v) to study the effects of arrowing on juice quality, length and weight of millable cane.

The conclusions drawn from the various experiments in the respective stations are furnished below :—

Anakapalle.—(i) Flowering is not an indication of maturity. There was a steady increase in sucrose content even for about two to two and a half months after arrowing, (ii) deterioration of arrowed canes began two to two and a half months after arrowing, (iii) arrowed canes showed a higher sucrose content than the non-arrowed canes for about two to two and a half months after arrowing, (iv) arrowed canes had more pith in cane, (v) rind hardness diminished gradually from bottom to top. Rind is harder in nodes than in the internodes throughout the length of the cane, (vi) most of the cane varieties reach their peak sucrose content in February-March, but the early varieties can be harvested from December-January and the latter ones from February-March, (vii) in general, the quality of jaggery improved gradually up to March, (viii) most of the varieties reached their maximum tonnage in March, (ix) arrowing induced earliness and the juice of arrowed canes had a higher coefficient of purity than the non-arrowed canes, (x) Co. 533 and Co. 527 had rich juice and the quality was maintained from February to April. B. 208 was the earliest of all varieties, (xi) maximum jaggery recovery of 14·09 per cent on cane weight was recorded by Co. 533 in March, followed by Co. 527 with 13·67 per cent in April. B. 208 gave the maximum outturn of jaggery in December combined with the best quality. Maximum recovery of jaggery was obtained from arrowed canes earlier than from unarrowed canes, (xii) highest commercial cane sugar per cent (sugar that can be manufactured from a cane of known analysis) was obtained from B. 208 closely followed by Co. 533.

Gudiyattam.—(i) Maximum sucrose was reached in the early varieties from December to January and in late ones from March. Co. 419 of the late group showed the highest sucrose of 20·28 per cent followed by POJ. 2878 of the early group with 19·58 per cent, (ii) maximum jaggery recovery was obtained when the sucrose percentage was the maximum, (iii) profusely arrowing varieties are to be crushed early on account of their early development of high sucrose than non-arrowing or sparsely arrowing varieties, which are to be harvested late, (iv) January-February for early varieties and March-April for late ones, are the best periods for jaggery making, both for outturn and quality, (v) arrowing commences by about the middle of October. Arrowed canes mature and deteriorate earlier than unarrowed canes, (vi) Co. 449, Co. 419, Co. 540, Co. 455 and Co. 535 recorded fairly high sucrose and purity among the varieties under trial.

Samalkota.—Of the varieties Co. 419, Co. 421, Co. 443, Co. 444, Co. 508 and Co. 349 tried Co. 508 recorded the richest juice with 21·21 per cent sucrose under arrowed and 20·03 per cent sucrose under unarrowed conditions. It was fit for crushing by November and continued to improve in quality right up to the end of March.

Palur.—Based on the results of the ripeness trials the following classification of varieties was made for that locality :—

Early—Co. 281, Co. 270 and Co. 414.

Midseason—Co. 281, Co. 270, Co. 414, Co. 331, Co. 349, Co. 408, Co. 413, Co. 421, Co. 430, J. 247, Co. 363 and Co. 407,

Late—Co. 363, Co. 407 and Co. 402.

There is some overlapping of some varieties in the successive season.

Arrowing in sugarcane.—The percentage of arrowing varies with the varieties, season, and environmental conditions. Some varieties do not flower at all, some varieties flower sparsely and in some, flowering is profuse. Extreme drought and ill-drained conditions induce flowering. Crops planted in February-March arrow by the end of October and beginning of November. Canes planted in May-June do not arrow ordinarily. Arrowing is less if the crop is well manured and grown under luxury conditions.

Swamp trials.—A number of varieties including Co. 419 were tried under swamp conditions, where water is let into the field in August and the crop was grown with standing water of one to one and a half feet depth till November. Co. 419 was outstandingly the best variety even under ill-drained (swamp) conditions, as also under drought conditions. The varieties mature earlier under swamp conditions by about a month and their juice is richer but the tonnage is poorer than those grown under normal conditions of growth.

Harvest operations.—Harvest of cane is done with heavy knives or hatchets. Heavier and sharper the tool, the easier is the harvest operation. The canes are cut flush with the ground level or even two inches to four inches below the ground. The canes are rich at the base, and even a small stubble left above the ground results in considerable loss. Soon after harvest, the canes are stripped of the trash (dry leaves). This is done using a sickle. In some varieties the trash firmly adheres and stripping is rather laborious; whereas in some varieties like Co. 419 and Fiji B the trash easily separates and even falls off by itself. After stripping, the canes are topped at the point of the crown. The cleaned millable canes are either carted to the factories or milled for jaggery making.

The trash is used as fuel for furnaces in jaggery making. Where the cane is sold to the Sugar Factories, it should be used for composting. The Venkataraman Sub-Committee (1950)

noticed that the use of pig dung as starter hastened decomposition of trash when composted and this was confirmed by preliminary tests conducted at Anakapalle and under ryots' conditions in Nellikuppam. In some places where collecting, carting and composting are found uneconomical and also for want of time, the trash is burnt *in situ*. Cane trash is a refractory material for composting and takes a long time for decomposition. In almost all places, trash is utilized in storing jaggery. In certain places the trash is used as thatching material also.

The green tops are fed to cattle. They are much relished and considered nutritious. They are specially fed to bullocks which put on good condition with this green feed. Dried tops are also used as thatching material.

Yields.—The average yield of cane varies from 20 to 45 tons of cane per acre and the yields of different popular varieties in different tracts are furnished in Appendix II. A maximum yield of 81·55 tons of cane was recorded at the Agricultural Research Station, Samalkota, in 1941–42 and about 96 tons under ryots conditions in 1950–51 season in Coimbatore and Godavari districts with Co. 419.

Trials to reduce cost of production.—At Palur, trials were conducted to reduce the cost of production. Co. 281, Co. 349, Co. 419 and POJ 2878 were grown, to select high yielding variety, using labour saving implements. " Pillipesara " and Sunnhemp were grown on ridges for application as green manure. Manures and irrigation water were used judiciously. The crop was neither trashed nor propped. The cost of production was reduced considerably and varied from rupees four to five per ton during the pre-war depression period 1935–37.

Ratooning.—After the harvest of sugarcane, under favourable conditions, fresh shoots come up. The growth of these shoots is often very vigorous in the early stages due to the well established root system. If this fresh growth is taken care of by proper cultivation, manuring, irrigation, etc., a good crop can be raised. This is termed ratooning. Ratooning of sugarcane was adopted even from very early times and in some tracts ratooning for five to ten years also was practised. With the experience gained in the different tracts with the ratoon crops, it is only advised to ratoon for once and not more. In ratooning, there is considerable (about twenty per cent) saving in cost of production. Cost of seed material and planting charges are entirely saved. Much of the preparatory tillage is avoided. With the well developed root system the shoots put forth vigorous growth in the early stages. Usually, 50 lb. more nitrogen per acre should be given to ratoon crops. All other operations are the same. The yield of ratoons is generally less due to neglect of such crops by the ryots. But there are instances where ratoon crops have given even higher

yields than plant crops. At present, ratooning sugarcane has become a general practice everywhere, but only one ratoon is recommended.

Ratoon experiments.—Experiments conducted at Anakapalle, Samalkota, Palur and Gudiyattam to study the various aspects of ratooning disclose the following conclusions :—

(i) Ratooning reduces the cost of cultivation by 20 per cent. At Gudiyattam Co. 213 was found to be the best ratooner, whereas J. 247 was a failure. The first and second ratoon of Co. 213 with increasing dose of manure at 200 and 250 lb. Nitrogen per acre gave 16 per cent and 11 per cent higher yields respectively than plant crops. It is therefore advantageous to take one ratoon of varieties that are good ratooners. As ratoons are more infested by diseases particularly 'smut', it is essential to maintain the vitality of the crop and field sanitation by adequate manuring, irrigation and clean cultivation. Ratoons mature earlier than plant crops and have to be harvested earlier.

(ii) At Anakapalle and Samalkota the results indicated that (*a*) plant crops recorded better yields than first or second ratoons, (*b*) it was found economical to ratoon once only, and (*c*) ratoons were richer and earlier to mature than plant crops.

(iii) It was most profitable to plant Co. 419 and ratoon it. Ratoons had richer juices and yielded higher jaggery recoveries. The percentage of arrowing was found more in the case of ratoons. The cost of production per ton of cane was the lowest in the case of Co. 419.

Carting cane to the factory.—When the sugarcane has to be carted to the sugar factories, only that quantity required for immediate carting is harvested, cleaned and carted. Care should be taken to avoid delay in carting after the harvest, as the canes get spoilt resulting in loss in recovery to the factory, and loss in weight to the cultivator.

Preparation of jaggery.—In the manufacture of jaggery there are two important processes, (i) the extraction of juice and (ii) boiling the juice into jaggery.

Extraction of juice.—Juice is extracted from cleaned sugarcanes by means of crushers. The popular modern designs are three-roller-iron, bullock-drawn crushers of different makes. These iron crushers have almost completely replaced the old wooden mills which were not efficient extractors. Power crushers are also in use for large scale crushing. Kirloskar's "Vasant" and "Sharat" crushers, and crushers manufactured by Aswinkumar Mandal, Calcutta and Rama Narayan Banerjee Mills are some of the popular ones in general use.

Mill trials.—The efficiency of a sugarcane mill is judged by its crushing capacity, percentage of extraction, low draught and durability. Trials with sugarcane mills of different makes—both

bullock drawn and power driven, were conducted at the Anakapalle, Samalkota and Gudiyattam Research Stations. The data obtained, indicated that there was not very much difference between the bullock mill and the power mill in the percentage of extraction, which varied from 65 to 70 per cent, but the crushing capacity of the power mill was nearly three to four times that of the bullock drawn one, being 1,167 lb. per hour, as against 336 lb. per hour, of the latter.

Boiling of the juice.—The fresh sugarcane juice is boiled into jaggery in large iron pans over specially constructed furnaces.

Furnaces.—Jaggery making furnaces vary very much in size, shape and pattern in different localities. The local or country furnaces are merely pits dug in the ground, consume more fuel and have no facility for the smoke to escape. *Sindewahi* furnace, an improved type of furnace, was introduced about three decades ago. This furnace has a number of advantages, such as, a passage in line with the feed hole for the smoke to pass through, a chimney for the escape of the smoke, a baffle wall in the centre of the furnace for the distribution of the flames, and an ash pit underneath from which the ashes can be conveniently removed. There is considerable saving in fuel in the Sindewahi furnace due to the optimum depth and dimensions of the furnace. The efficiency and economy of the Sindewahi furnace were proved by various trials in all the jaggery making localities in this State and also in the Sugarcane Research Stations.

Fuel for jaggery furnaces is usually the trash (dry leaves) and the bagasse or megasse (the residue left after the extraction of juice from cane). Normally, the available quantities of trash and bagasse will be quite sufficient, when improved furnaces are adopted. Where there is wastage of fuel, as when country furnaces are in use, other available waste materials like stalks of redgram, castor, cotton, chilli, tobacco and cheap forest fuel, etc., are also used in addition.

The pans for boiling the juice are generally made of iron material. They are usually flat bottomed and circular, seven feet in diameter and two feet in depth. In some localities, round bottomed hemispherical pans are in use. In some other places, flat bottomed pans with sloping sides are used. The capacity of the pans normally vary from 500 to 1,000 pounds of juice per charge depending upon the size.

Process of boiling.—The juice is poured into the pan through strainers to remove the suspended impurities. With the full charge the pan should be only 1/3 to ½ full, leaving sufficient clearance for the juice to boil. Then the furnace is lighted and the fuel is fed uniformly to maintain maximum flame to quickly raise the temperature. The raw juice is acidic in reaction and before boiling it should be made neutral. For this purpose a

small quantity of slaked lime is mixed in water and the lime solution is added to the juice. The quantity of lime to be mixed is decided by experience and it is necessary to keep the juice slightly alkaline. Care should be taken to avoid excessive liming as it darkens the colour of the jaggery. In neutral medium the juice easily gets clarified and all the impurities in the juice such as the colouring matters, waxes, gums, etc., get coagulated and float as a scum which is removed. In some places, the juice of *bendi* (*Hibiscus esculentus*) is also added for clarification. The scum is carefully removed with scum strainers or perforated laddles intended for the purpose. By the time the scum is removed completely, the juice begins to boil. During the boiling stage, the water in the juice gets evaporated and the juice gets concentrated into syrup. Any impurities or scum that come up during boiling are carefully removed. As the concentration increases foaming and frothing subside. The syrup assumes bright yellowish brown colour. The syrup boils with small pearly bubbles. At this stage, to improve colour, a small quantity of milk is added in some places. This is said to impart golden yellow colour. But excess of milk slightly softens the jaggery. From this stage onwards, the flame is carefully regulated to avoid the possible caramelisation of the syrup, which is prevented by continuous and vigorous stirring. This is done with stirrers provided with long handles. As the concentration progresses, the syrup gets thickened. When the end point is reached, the pan is removed from the furnace and kept by the side on a platform and the contents are very vigorously stirred to effect quick cooling which results in good crystallisation and bright colour. When the contents assume semisolid condition, the contents of the pan are carefully collected to one corner with wooden scoops and finally transferred into moulds, etc., according to the local practice.

Different methods are adopted in different localities in jaggery making. In some places nothing at all is added to the juice, either for clarification or for colour. In certain places, only lime is added but not milk and vice-versa in certain others; whereas in some localities both lime and milk are added. These practices often depend upon the local customs and are also based on age-long experience.

The final shape of moulded jaggery varies largely from tract to tract. In North Visakhapatnam the jaggery is poured into pots and allowed to solidify in them, each pot weighing from 18 to 25 pounds net. In South Visakhapatnam it is moulded in baskets and each mould may weigh about 25 to 30 pounds. In Godavari, jaggery is moulded into thick slabs. In Chittoor it is made into big balls. In the South, small cubes are made and in some parts it is also converted into powder. Thus the final form in which jaggery is offered for sale differs from place to place.

Characteristics of jaggery.—Good jaggery should possess the following qualities :—

(*a*) *Colour*—Golden yellow is the best.

(*b*) *Hardness*—Jaggery should be hard and should not be easily scratched with the finger nail.

(*c*) *Sound.*—Ringing metallic sound when tapped indicates good quality.

(*d*) *Smell*—It should be free from any unpleasant smell. It should have the typical jaggery flavour.

(*e*) *Crystallisation*—The inner core should be whitish with fairly large sugar crystals.

(*f*) *Keeping quality*—Good jaggery should maintain the hardness for a long time. It should not absorb moisture during the wet weather and must be free from sweating.

(*g*) *Taste*—The taste should be sweet, and free from either acidic or saltish taste.

(*h*) *Cleanliness.*—It should be free from impurities as sand, dust, etc.

Jaggery making trials.—In Coimbatore district and round about, cube jaggery generally commands a higher price than lump jaggery and it has been the experience that when purity of cane juices falls down to about 80 per cent to 82 per cent, the preparation of cube jaggery becomes very difficult. In such cases, either lump jaggery is prepared or very dark cube jaggery is made by the addition of excess of lime. Experiments conducted in the laboratory with a view to obtaining a better coloured cube jaggery from low purity juices gave satisfactory results with the following method :—

Superphosphate, to the extent of 0·1 to 0·2 per cent of the juice by weight, is added to the cold juice and lime added immediately after, to bring a reaction very slightly acid to litmus. The juice is then boiled, scum removed, and lime added to a reaction just alkaline to litmus. The boiling is continued for a few minutes and the juice is allowed to settle down in a separate pan for 15 to 20 minutes. The golden yellow supernatant juice is syphoned and concentrated in the usual way, the mass get ready to enable the preparation of cube jaggery and the product so obtained is of a satisfactory colour.

With some juices, it has been found necessary to place the concentrated thick mass of final syrup over a boiling water-bath for about 10 to 15 minutes to make it crystallize before transferring into the proper mould. The cube jaggery prepared as above from low purity juices is inferior in keeping quality to that prepared from high purity juices.

Cream jaggery trials.—With a view to improve the colour of jaggery, attempts were made to prepare white jaggery called " Cream " jaggery by clarification of the juice. It was also

expected that the product would fetch a high price. For this purpose, the hot juice after the removal of scum is filtered through what is called "activated carbon". The filtrate which is decolourised is concentrated in the usual manner preferably in shallow copper pans with sloping sides. This results in almost white jaggery called 'cream jaggery'. Special propaganda was made to popularise this method. The limiting factor was the supply of activated carbon which could not be made by the cultivators. It had to be supplied by the Government from the Research Institute at Coimbatore or from other Research Stations, which could not cope up with the demand. In addition, the cost of the activated carbon was also high. The filtration process was slow and the net recovery of jaggery was slightly lower. Due to these defects the process could not be adopted as a general practice.

Sugar manufacture by open pan system.—In this process a specially constructed furnace with a battery of five pans called the "Rohilkhand Bel" is used. The capacity of the pans to boil at one time is about 4,000 lb. of juice. Usually, in this process, boiling is taken up non-stop from the beginning to the end for economy and convenience. When the juice is heated to 85° to 90° C the scum is formed which is carefully removed. After the removal of the scum "bendi" (*Hibiscus esculentus*) juice should be added, and the juice boiled again removing the scum as it is formed. Soda ash at eight ounces dissolved in 14 lb. of water for every 1,000 lb. juice is next added and further removal of the scum is done. When the juice in the fifth pan attains a temperature of 110° C the concentrated juice, is removed, cooled for 20 minutes and put into earthen pots. The rab in the earthen pots is stored for about a week for crystallisation before it is centrifuged. The rab from the pots is removed by breaking the pots. The contents are well mixed up and centrifuged in a centrifugal machine. The white sugar adhering to the sides of the centrifugal is scraped and dried in sun. The molasses that is obtained as a byproduct may be mixed with fresh juice in the proportion of 1 : 5 or 1 : 6 and prepared into jaggery, or it may be further concentrated to obtain the second sugar. A 15 inches centrifugal machine can deal with 1,000 lb. of rab in a day of ten working hours. It is not absolutely necessary to have only the special furnace with battery of pans. Even the ordinary furnaces like Sindewahi can be used for the preparation of rab. But a centrifugal machine is essential and to work it an oil engine or electric motor is required. Due to large demand for jaggery in this state the cultivators are only accustomed to prepare jaggery. The recovery of sugar by open pan system is comparatively low about five per cent. The second sugar obtained from molasses is of inferior quality. It is not practicable for all cultivators to own an oil engine and a centrifugal. For these economic reasons, this system did not find favour in Madras State unlike in North India where it is largely in vogue as a cottage industry.

Nutritive value of sugarcane products—

	Sugarcane juice. PER CENT.	Jaggery. PER CENT.
Moisture	90·2	3·9
Protein	0·1	0·4
Fat (ether extractives)	0·2	0·1
Mineral matter	0·4	0·6
Carbohydrates	9·1	95·0
Calcium	0·01	0·08
Phosphorus	0·01	0·04
Iron	1·1 mgs.	11·4 mgs.
Calorific value per 100 gms.	39	383
Carotine-international vitamin A units.	10	280
Calories per ounce	11	109

Storage.—Jaggery when exposed to damp weather absorbs moisture and becomes soft. In bad cases it becomes semi-solid. When the quality is lost the value decreases very much. As such, great care is necessary in storing. When large stocks are handled it is stored in godowns. Jaggery is piled up with trash in between the layers, or convenient quantities are tightly bundled up in palmyra leaves or mats or baskets. The *godowns* should be damp proof. They should also be proof against the common storage pests like rats, ants, etc. During the wet weather, stored jaggery is smoked in godowns.

Pests and diseases of sugarcane—(1) *Pests.*—There are five important pests on sugarcane, viz., 'early shoot borer', 'late shoot borer', 'top shoot borer', 'cane fly' and 'grass hopper'. Details about these and their control are dealt with under Crop Pests in Chapter 22.

(2) *Diseases.*—Smut is the common and serious disease of sugarcane in the State. Red rot and mosaic proved to be of importance in this State before the introduction of Coimbatore canes into cultivation.

Sugar industry and protection.—Sugar is an important article of food and as such it is an important commodity in International Trade. Prior to 1800, sugar produced from cane was the only commercial product but in 1801, the technique of extracting sugar from another plant, viz., Beet, was perfected by Germany. At present out of a total production of about 34 million tons of sugar, about 25 million tons are from cane and 9 millions from Beet. In the beginning of this century, every country encouraged sugar industry and with rehabilitation of the Beet Sugar Industry in Europe after the first World War, there was a surplus of 1 million tons of sugar every year. Export quotas were fixed for surplus countries like Java, Cuba and Germany to check undue competition, according to an international agreement referred to as "Chad bourne plan". The sugar industry in India developed rapidly, after the tariff protection granted by the Government in 1932

under the Sugar Industry (Protection) Act of 1932. Protection to the sugar industry was granted for a period of 14 years ending 31st March 1946. The protective duty of Rs. 7–4–0 per cwt. was in force until 31st March 1938. In the Sugar Industry Protection Act, however, a statutory provision was made for an inquiry to be held before 31st March 1938 to enable the Government to determine what measure of protection should be adopted for the remaining period of 8 years. On account of protection, there was a rapid expansion of the sugar industry and production began to increase very rapidly. Thus, the number of vacuum pan factories increased from 29 in 1930–31 to 57 in 1932–33, and 112 in 1933–34. During the same period the production of sugar in vacuum pan factories rose from 120,444 tons to 454,000 tons. At the same time, there was a series fall in the customs revenue on sugar from about rupees ten crores in 1930–31 to about two crores in 1933–34. It was found that the benefit of protection had been reaped entirely by the factory owners and not by cane-grower for whose benefit the protective scheme had been primarily devised. In 1934, therefore, Government reviewed the whole position and decided on a two-fold line of action. On the one hand, they imposed an excise duty on factory produced sugar so as to recoup a part of the sugar revenue lost through protection, and, on the other hand, they passed legislation enabling State Government to enforce a minimum price to be paid by the factories to the cane-grower. The excise duty was fixed at Rs. 1–5–0 per cwt. and this reduced the amount of protection from Rs. 9–1–0 to Rs. 7–12–0 per cwt. Under the Finance Act, 1937, while the import duty was raised to Rs. 9–1–0 per cwt., the excise duty on sugar was increased from Rs. 1–5–0 to Rs. 2 per cwt. Towards the end of 1937, Government appointed a Tariff Board to enquire and report as to what amount of protection should be granted to the industry after 31st March 1938. The Tariff Board in its report submitted in December 1937, recommended that protective duty of Rs. 7–4–0 per cwt. should be levied for a period of 8 years ending 31st March 1946. Pending Government decision on the Board's report, the then existing protective duty of Rs. 7–4–0 per cwt., was extended by one year from 1st April 1938, to 31st March 1939. In the meantime, the price of imported sugar had gone up to some extent. Moreover, in 1938, the Governments of the Uttar Pradesh and Bihar had adopted an extensive system of control over the sugar industry, imposed a cess on cane supplied to the factories, and decided to enforce minimum price regulations more rigidly than in the past. The Government of India took account of these changes and decided to extend protection by two years ending 31st March 1941. The amount of protective duty was fixed at Rs. 6–12–0 per cwt., i.e., eight annas less than that recommended by the Board. Government also proposed that a fresh enquiry should be held in 1940, so as to enable them to decide what amount of protection should be given after 31st March 1941. In March 1940, the excise duty on factory sugar was

increased from Rs. 2 to Rs. 3 per cwt., and to offset this, the total import duty (protective duty plus excise duty) was raised from Rs. 8-12-0 to Rs. 9-12-0 per cwt. In April 1942, a revenue surcharge of 20 per cent on the import duty was imposed and the total duty was thereby raised to Rs. 11-11-2 per cwt. This duty was continued from time to time without a fresh inquiry until 31st March 1947.

The Tariff Board held a summary inquiry in February 1947 and recommended that the then existing protection should be continued for a further period of two years ending 31st March 1949, and that a tariff inquiry should be instituted during the later half of 1948. In the first instance the protective duty was continued by Government till the 31st March 1948, and later on by another order till 31st March 1949.

In April 1948, the Government referred the case of the industry for continuance of protection, to the Tariff Board for investigation. An inquiry was held in December 1948, and the Tariff Board recommended that protection should be continued for a period of two years ending 31st March 1951: and suggested that there should be a detailed inquiry at the beginning of 1950 in order to determine the quantum of protection, if any, that would be necessary after the 31st March 1951. After referring the matter to the Central Legislative Assembly for consideration, the Government continued protection to the industry for a period of one year only, that is, till the 31st March 1950. Thereafter it was abolished.

As a result of protection given to the industry the import of 8-lakh tons of sugar in 1930 was reduced to 38,000 tons in 1936 and is practically negligible now.

Schemes under Sugar Excise Fund.—A part of the excise duty on sugar was set apart for helping the sugarcane growers in India. During August 1937, the Government of Madras submitted a five-year scheme to the Government of India which aimed at rendering assistance to the sugarcane growers in the factory areas of this State. The main idea of the scheme was to adjust the sugarcane cultivation in the factory areas to suit the requirements of the factories, and to formulate suitable cultivation practices to achieve this object. It was decided that the grant should be spent through co-operative societies or unions of cane-growers in factory areas. Each society was provided with a certain amount of capital for the purchase of implements, rubber tyred carts for transport, necessary apparatus and equipment, and seeds and manures. In some factory areas there were already societies and they were affiliated to the unions which were set up for this specific purpose to control the working of the soieties. The unions employed co-operative and agricultural staff lent from the respective departments.

There were ten centres of work in the State in the factory areas as shown below :—

District.	Location of the factory.
Visakhapatnam	Bobbili. Thummapala. Etikoppaka.
East Godavari	Kirlampudi.
Krishna	Vuyyuru.
Bellary	Hospet.
North Arcot	Mailpatti.
South Arcot	Nellikuppam.
Coimbatore	Podanur.
South Kanara	Kalyanpur.

The scheme started work from the beginning of 1938. Very useful work was done in all the centres and there was substantial progress in all the objectives set forth in the scheme. As a result, in all the factory areas, the improvements suggested for sugarcane cultivation were put into practice to a large extent.

Sugarcane Ancillary Scheme.—This was a scheme financed from the Sugar Excise Fund. Under the scheme, the results of sugarcane research in the various stations were tried in the growers' lands in factory areas, to test the suitability of the proved results of research in the respective localities, so that the successful items could be safely recommended in the tracts concerned. The land owner had to bear all the normal cultivation charges except seed material, manures, and extra cost incurred for certain operations. All the produce was given to the owner. Suitable varietal, manurial and cultural trials were conducted in all these ancillary schemes (schemes ancillary to the Indian Council of Agricultural Research Schemes) in the following places :—

District.	Place.	Duration.
Visakhapatnam	Bobbili	4 years.
Do.	Palakonda	3 „
East Godavari	Kirlampudi	4 „
Do.	Ramachandrapuram	3 „
Krishna	Vuyyuru	4 „
North Arcot	Tirupattur	2 „

In these trials, many of the findings in the Research Stations were confirmed and the outstanding improvements demonstrated to the growers. The successful varieties for early mid-season and late crushing, optimum and economical doses and forms of manures, and use of labour-saving implements for after-cultivation could be spread in the tracts.

Sugarcane Research Scheme.—This scheme was initiated in January 1947 and is being worked out at Anakapalle and Gudiyattam on the usual share basis.

This scheme envisages detailed study of varieties released from Coimbatore, a manurial schedule, ratooning and tolerance to swamp. In the division of Chemistry, nitrogen nutrition of sugarcane, foliar diagnosis, factors influencing quality of jaggery and their relationship to composition of juice, are the main lines of

work in progress. In the division of physiology, water requirements of plant and ratoon crops of sugarcane, tissue moisture in relation to sucrose content, factors influencing maturity of sugarcane, and root system are the studies in progress. In the division of Mycology, varietal resistance to smut, and modes of dissemination and carry-over of smut are the items of research. In the division of Entomology, evaluation of loss due to borers and methods of control are being investigated.

Sugarcane Development Scheme.—In March 1949, the Sugarcane Development Scheme was initiated with financial assistance of the Indian Central Sugarcane Committee. The object of the scheme is to increase the average yield of sugarcane in the State by at least 20 per cent, to assist the cane growers in cultivation of the crop, and to increase the recovery per cent in sugar factories. Four Liaison Farms were started in Samalkot, Hospet, Kulittalai and Nellikuppam. These Liaison Farms serve as regional centres for testing varieties and improved methods of cultivation. Seed material of improved varieties are multiplied and released to the cane growers. Special Agricultural Demonstrators are posted in important cane centres and these technical men carry on propaganda among the cane growers and carry the results of research to the doors of cultivators. They watch the appearance of pests and diseases and take prompt control measures in co-operation with the Plant Protection Staff. After the initiation of the Sugarcane Development Scheme, the standard of cane cultivation is on the increase.

The working of Gur Control Order in Madras State.—The Gur Control Order regulating the inter-Provincial movement of jaggery (gur) came into opertions on 1st November 1943 during the second World War.

Madras is a surplus State as regards jaggery (gur) and the excess over State requirements which in normal times used to be freely exported to neighbouring States, was controlled and regulated under the above order. Export quotas from Madras were allotted to the adjoining States by the Gur Controller for India.

The above quotas based on the geographical situation of the importing areas and normal trends of movement were generally found suitable for the export of the surplus gur of this State.

As contemplated in the Gur Control order the despatches of gur were made from this Government to the Governments of other States, within ceiling rates approved by the Government.

Effect of the Gur Control Order.—By the method of Government purchase and despatch, the Gur Control Order was mainly advantageous in keeping down prices and conserving and regulating supplies of jaggery. The prices which were steadily increasing till January 1944 declined to reasonable limits.

System of export under private permits.—With effect from the 9th of August 1944, a new method was introduced by which exporters were allowed to despatch jaggery to their own consignees in other States under permits, issued to them within the ceiling rates and on payment of a surcharge of two annas per railway maund. This created a large rush for export permits.

It was found that the new system provided for a more rapid disposal of accumulated stocks. There was, however, a rise of prices in the markets, due to the activities of permit-holders and merchants to get hold of the stocks. Some States like Cochin and Hyderabad, however, desired to continue the old system. This was because the quality of jaggery supervised by the marketing staff was generally satisfactory.

MADRAS JAGGERY (MANUFACTURE) CONTROL ORDER, 1949.

In view of the imperative necessity to maximize sugar production and in order to prohibit the diversion of sugarcane for the manufacture of jaggery, the Government promulgated the Madras Jaggery (Manufacture) Control Order, 1949, banning the manufacture of jaggery except under a permit. Power has also been taken to apply the provisions of the Order to the whole or any portion of the State by a notification by the Government.

CANE JAGGERY (MOVEMENT) CONTROL ORDER.

The Government have issued the Madras Cane Jaggery (Movement) Control Order, 1950, which forbids the transport of cane jaggery from any place in Madras State to any place outside it by rail, except under a general or a special permit issued by the Commissioner of Civil Supplies. This order was passed to control the price of jaggery in factory areas with a view to encourage supply of cane to sugar factories.

MADRAS SUGAR FACTORIES CONTROL ACT, 1949.

Under this Act, the Director of Agriculture is the Cane Commissioner and Chairman, and the Sugarcane Specialist is the Secretary of the Advisory Committee in which the sugar factories, sugarcane growers, jaggery merchants and consumers are represented. Cane Inspectors are appointed for enforcing the provisions of the Act. Under this Act, sugarcane areas are declared reserved for the factories. From the ' reserved ' areas, cane should not be transported for sale to another factory. Canes are to be offered by ryots on the basis of prior agreement in writing with the factory. The minimum price for cane is fixed by Government. The weighbridges, weights and the records are periodically inspected by Cane Inspectors. Cess on cane purchased by the factories is levied at Re. 1 per ton and the amount so collected is intended to be spent on Research and Development of cane in the State.

THE INDIAN CENTRAL SUGARCANE COMMITTEE.

Formation, functions and funds.—This Committee was inaugurated on the 29th November 1944, by the Government of India. The Committee was fully represented by various interests of sugar industry, viz., the growers. It is well recognized that representation of all interests is essential for the achievement of a co-ordinated policy. Originally the Committee had 45 members in all on its roll, of whom sixteen were ex-officio members, including the ex-officio President, and nine representatives were nominated by Indian Sugar Mills' Association. There were three nominees of the Sugar Trade, one of the Sugar Factory-owners, four representatives of the *Gur* and *Khandsari*, three of the consumers, one nominee of the Sugar-Technologists' Association. There were eight non-officials, representing agricultural interests, nominated respectively by the Governor-General-in-Council and the Government of Madras, Bombay, Bihar, Uttar Pradesh and the Punjab. To this number of members the Sugar Controller for India and one representative of the Industries and Civil Supplies Department of the Government of India were subsequently nominated by the Governor-General-in-Council.

Prior to the formation of the Indian Central Sugarcane Committee, the responsibility for guiding sugarcane research in India and for advising the Central State Governments on matters relating to improvement and development of the industry connected with sugarcane and its products, rested mainly with the Sugar Committee, appointed by the Indian Council of Agricultural Research, and partly with the Indian Institute of Sugar Technology, Cawnpore, which was under the control of the Government of India.

The proceeds of the Sugar Excise Fund, to which funds are credited at the rate of one anna per cwt. of white sugar produced in India, out of the Excise Duty levied thereon, were utilized for the maintenance of the Indian Institute of Sugar Technology and for sanctioning grants to the State Governments for expenditure in connexion with schemes of sugarcane research and development.

On the formation of the Indian Central Sugarcane Committee in November 1944, the responsibility for undertaking the improvement and development of sugarcane marketing and manufacture of sugar and sugarcane products in India, and all matters incidental thereto, were vested in the Committee. The main lines of work undertaken by the Indian Central Sugarcane Committee either under its direct control or through schemes by it, included :

(1) the production, distribution and testing of improved varieties of sugarcane under different sets of soil and climatic conditions ;

(2) the testing of improved cultural, manurial and irrigation practices ;

(3) the study of sugarcane diseases and pests, including the biological control of borers, etc.;

(4) the technological and economic research on sugar and its by-products;

(5) the manufacture of Khandsari sugar and gur, by improved methods;

(6) the grading and storage of white sugar, Khandsari sugar and gur; and

(7) the improvement of crop forecasting and sugar statistics.

During the year 1948–49 the Committee continued to maintain the Indian Institute of Sugar Technology which serves as a teaching, as well as a research institution and which is also responsible for the maintenance of Sugar Standards, preparation of the returns under the Sugar Production Rules, Sugar Trade Information Service and for taking up any other special work connected with sugar as and when required by Central or State Governments.

The annual net receipt of the Government of India from the Sugar Excise duty amounts to over Rupees seven crores and the grant of about 50 lakhs out of this amount to the Indian Central Sugarcane Committee for the expansion of its activities was justified. The Committee is working at present on the basis of an annual grant of only rupees ten lakhs. The question of the necessity of increasing the grant to the Committee for purposes of research was examined by the Tariff Board of 1950, and we hope that as a result of their recommendations, the Government of India will restore their grant to the Committee at the rate of annas four per cwt. of excise duty on sugar, as it is essential to undertake intensive research work for tackling the problems of sugarcane which are vital for the establishment of the industry in the country on sound lines at an early date.

State Sugarcane Committee.—In this Committee, non-officials representing sugar factories, sugarcane growers, and jaggery merchants and officials from the Agricultural, Co-operation and Industries Departments are members. The Director of Agriculture is the Chairman and the Sugarcane Specialist is the Secretary. The Committee usually meets twice a year to discuss matters of importance in cane cultivation.

Special Sugarcane Sub-Committee.—On the recommendations of the State Sugarcane Committee a special Sub-Committee was appointed in 1950, to enquire and report on the technique of cane cultivation in the factory areas, to recommend improvements in the same and to draw up a plan for maximizing sugar production in the State. The Special Sub-Committee was constituted under the Chairmanship of Dr. T. S. Venkataraman with the Sugarcane Specialist as Secretary. This Special Sub-Committee toured all the factory areas of this State and the salient features from its report are briefly mentioned below,

The cost of cultivation of sugarcane could be ultimately lowered at least to the level of sub-tropical belt in India. The future industry should be located in areas considered suitable for sugarcane and the licensing should be so issued as to avoid mutual competition due to nearness. The opinion that 800 tons factory is the lowest economic unit may not be applicable to this State and round about 450 tons may be the lowerst limit for joint stock companies and as low as 75 tons for co-operative units. The relationship between the grower and the manufacturer should be brought together and the Committee recommended provision of amenities to cane growers, supply of sugar and by-products, expeditious release of cane carts and help in transport of canes. By co-operative and joint farming efforts, cane should be grown in large size blocks as is being done in Vuyyur. There is scope for considerable economy in the manure bill and the Committee recommended growing of green manure crops and utilization of factory wastes. In regard to irrigation, it is essential to locate the industry in the areas where water is available in plenty and at cheap rates. There is need to replace manual labour by bullock and mechanical power. Wrapping and propping as practised in South Visakhapatnam and Godavari districts put up yield by 10 to 15 tons. Though there is justification for the continuance of the practice, there is immediate need to cheapen the cost of the operation by use of vertical posts more durable than bamboos or by trash twist methods. To cheapen transport, conditioning of feeder roads and organization of tractor trailer units were recommended. The Committee recognized the potentialities of the Sugarcane Liaison Farms in bringing together the interests of growers and the manufacturers.

The following are the salient features in regard to action taken on the recommendations of the Special Sugarcane Committee :—

Vuyyur.—Setts are usually superficially planted and drains are not provided. Such practices increase the tendency to lodge. The cane development staff did sustained propaganda and trench planting and provision of drains were demonstrated in 88 acres in 1950–51 season. Over 1,400 acres were propped by the cheap trash twist method of propping which costs only Rs. 20 per acre. Time and mode of application of manure were defective and in 1951–52 season, the cane growers have switched over to early application of manure close to the clumps and covering the same by working implements. Consolidation of cane areas into large size blocks has been effected by the factory by encouraging registration of areas in such large blocks of over 150 acres. Trials with pig dung as starter for cane trash compost were discontinued by the factory, but experiments conducted at Anakapalle indicate that pig dung hastens decomposition of cane trash and further experiments are in progress.

Samalkot.—The sugar factory is issuing cutting orders to the limit a cane grower can transport canes to the factory, but such concessions are not availed of by small growers who cannot afford

to hire out carts for transport of their canes. Under the delta conditions the soil is treacherous and as such the methods of cheapening propping by the adoption of trash twist and propping is yet in the initial stages of test here. In the upland areas, this cheap method of propping is on the spread. Use of tops as planting material in this area is limited by water-supply and the sprouts from top buds are reported to be less resistant to drought and the latter is under investigation. The factory is not restricting the issue of advances only to such growers who purchase manure mixtures. The breaches in the Yeleru river have been closed.

Anakapalle and Etikoppaka.—To improve the contact between the factory at Thummapala and the growers, the factory has just organized a cane department and it is expected to strengthen this further. There is no development staff in this area, but the Research Station has been establishing contacts with the cane growers and advocated the use of tops as seed and use of implements for interculture and proper application of manure. The Co-operative Sugar Factory at Etikoppaka has expanded into a 600 tons factory which is now under erection.

Bobbili and Seethanagaram.—Irrigation facilities were not increased in the tract. The newly erected sugar factory received supply of electricity. The factory has not installed an automatic weighbridge. Use of implements for interculture is becoming popular in this tract.

Nellikuppam.—Drought continued in this area due to the failure of north-east monsoon. The factory preferred to sell out the press-mud by auction and did not arrange for effective distribution among the cane growers. The development staff has been popularising composting of cane trash and 290 pits were opened in 1950–51 season, and Rs. 1,051 were distributed as subsidy for composts. There is heavy loss in transport by rail due to pilferage in transport. Propping of canes by the cheaper method is increasingly popular and over 2,801 acres were propped this way in 1950–51. On the recommendation of the sub-committee, the factory authorities clean up canes, if necessary, at the cost of the cultivators. Co. 419 was re-introduced in the factory area for trial and was cultivated in 45 acres in 1951–52 and is proposed to be raised in about 300 acres in 1952–53.

Kodai Road.—The cane growers here are comparatively new to cultivation of cane. In 720 acres tops were used as planting material. In 1795 acres implements were used for interculture operations. Growing green manures is comparatively new to the tract. In 1950–51 season, this was demonstrated in 14 acres and in 1951–52 it has spread to over 200 acres.

Pugalur.—The Development Staff advocated and emphasised selection of seed material for planting, and reduction of seed rate. The bridge across the Cauvery is expected to be opened in 1952 and then the cane supply area will shrink, thus bringing about

reduction in cost on transport of raw materials. The cane growers have not learnt the benefits from green manure crops and utilization of trash and press-mud as manure.

Hospet.—The use of tops as seed material is being encouraged in this area. Use of trash for composting is demonstrated to cane growers; who burn the same for easy disposal. By the enforcement of Pest Control Act, incidence of smut was brought down to normal level and in 1951–52 season ratooning was permitted. The delay in the release of cane carts was considerably reduced by the regulation of issue of cutting orders.

Varietal Sub-Committee.—On the recommendation of the Special Sugarcane Sub-Committee a Varietal Sub-Committee was constituted in 1951, under the Chairmanship of Dr. T. S. Venkataraman. The Sub-Committee toured the factory areas and in consultation with the cane growers, the factories and the Sugarcane Development Staff, recommended the list of varieties suitable for cultivation and varieties to be withdrawn from cultivation.

Conclusions with discussion on future.—From the foregoing it is evident that sugarcane cultivation and sugar industry made considerable progress during the past half a century. The general standard of cultivation has improved. The average outturn per acre has increased. Improved varieties are under cultivation. Better methods of manuring are being adopted. Labour saving methods in cultivation practices are becoming more and more popular. In spite of all these facts, the State still lags far behind the advanced sugarcane countries. The yields have not yet come to their standard and the cost of production is still high. There is still abundant scope for improvement in every direction. In regard to sugar production, India is said to have attained self-sufficiency, but the Industry is not yet stabilized nor is its financial structure sound.

As far as the State is concerned, much more financial aid can be given towards research on sugarcane, both agricultural and technological. A well laid out programme by experts for each State has to be followed till the targets are achieved.

Research.—The research work done so far on sugarcane can be said to have just touched the fringe of the problem. Fundamental data on important items of sugarcane cultivation are not yet available. Correlation studies between weather conditions and growth, maturity and incidence of pests and diseases in sugarcane for different localities is worth studying as a long range problem. Soil surveys of important sugarcane tracts is badly wanting and the data may be useful for fixing manurial doses. Much work has yet to be done towards the protection of the crop from common pests and diseases. Improvement in jaggery making has yet to be experimented in detail to suggest practicable methods under ryots conditions. Though early and late maturing varieties are available

their cultivation is still restricted, as the factories are not able to pay sufficient premia for them to cover the loss in tonnage. As such, the factories are not able to extend the crushing season substantially due to financial limitations. Such problems have to be examined and if necessary, subsidies have to be granted to encourage the cultivation of early and late varieties. There are at present only two research stations at Anakapalle and Gudiyattam, concentrating work on sugarcane. Some more stations for other localities like Chittoor and Krishna may be necessary. In other localities the existing Research Stations, viz., Samalkota, Maruteru, Aduthurai, Palur, Siruguppa, Taliparamba, etc., can also be entrusted with sugarcane improvement work required for the respective tracts.

In regard to the breeding aspect, possibilities have to be explored to evolve varieties with more sugar, which give higher tonnage, which can resist pests and diseases and which are non-lodging.

Extension work.—The yield trials in the Research Stations have definitely proved that it is possible to obtain fairly good tonnage of about 60 to 80 tons and over per acre. If in every tract every grower is made to cultivate under similar lines, it is possible to raise the average yield by 50 per cent more at least. All possible efforts should be diverted towards this achievement. Even with the existing area under cane, more sugar factories can be established on sound basis. The capacity in the existing small factories can be enhanced to the economic standard of 800 tons.

Above all, more propaganda is essential to introduce the improvements rapidly, and for this purpose special staff in sugarcane areas for this specific purpose may prove useful.

Sugar industry.—On the industrial side there is still ample scope for improvement. The purchase of cane based on sucrose content is beneficial both to the factory and the cultivators in which case the latter will be compelled to pay attention towards the quality of cane also. But this is not practicable as innumerable small growers supply canes to the factories. Jaggery making as a cottage industry from palmyrah and date juices should be encouraged and these jaggeries can be refined in sugar factories in the off-season. Profitable utilization of molasses for the manufacture of alcohol, yeast, etc., will be advantageous for the factories. Much can be done in all these directions and there is great scope in India and particularly in Madras State for substantial improvement in sugarcane cultivation and there is every possibility to expand the sugar industry and sugar output to make this State one of the main exporting centres of the world in regard to sugar.

STATEMENT I.—*Statement showing the acreage under improved varieties of sugarcane in 1947–48.*

Districts.	Improved varieties.	Local varieties.	Total.
	ACS.	ACS.	ACS.
1 North Visakhapatnam ..	10,471	..	10,471
2 South Visakhapatnam ..	11,510	3,476	14,986
3 East Godadari	13,196	1,896	15,092
4 West Godavari	9,000	207	9,207
5 Krishna	4,082	..	4,082
6 Guntur	..	183	183
7 Kurnool	300	650	950
8 Bellary	12,450	296	12,746
9 Anantapur	7,000	782	7,782
10 Cuddapah	1,450	50	1,500
11 Nellore	..	..	..
12 Chingleput	..	..	..
13 South Arcot	21,750	10,000	31,750
14 Chittoor	22,000	1,100	23,100
15 North Arcot	33,200	1,535	34,735
16 Salem	16,574	200	16,774
17 Coimbatore	9,258	..	9,258
18 Tiruchirappalli	23,780	225	23,005
19 Tanjore	1,534	2,262	3,796
20 Madurai	8,900	400	9,300
21 Ramanathapuram	250	..	250
22 Tirunelveli	85	658	743
23 Malabar	190	..	190
24 South Kanara	5,150	..	5,150
25 The Nilgiris	..	..	..
Total for the State ..	211,130	23,920	235,050

STATEMENT II.—*Statement showing average yield of sugarcane per acre for each district* (1943–44).

Name of the district.	Name of dominant variety.	Average yield per acre in tons.
Visakhapatnam	Co. 419	25 to 30
East Godavari	Co. 419	40
West Godavari	Co. 419	35
	Purple Mauritius	28
Krishna	Co. 419	35
Bellary	Co. 419	28
Anantapur	Co. 419	34
Chittoor	Co. 419	35
	J. 247	25
	Striped Mauritius	28
Chingleput	Co. 419	32
Salem	Co. 419	40
South Arcot	Co. 281, POJ. 2878 and Co. 349.	23
North Arcot	Co. 419, Co. 421, Co. 281, J. 247 and POJ. 2878.	28
Tanjore	Co. 281	30
Tiruchirappalli	Co. 281, Co. 419, Co. 353 and Co. 258.	38
Ramanathapuram	Co. 419	24
Madurai	Co. 419	35
Coimbatore	Co. 419, Co. 421 and Co. 413.	34
Tirunelveli	Red Mauritius	25
Malabar	Co. 408, Co. 417, Co. 419 and Co. 421.	21
South Kanara	Co. 419, Fiji B and Red Mauritius.	22

STATEMENT III.—*List of Sugar Mills in Madras State in 1942.*

Name of factory, with full name and address of managing agents or proprietors. (1)	Location. (2)	District. (3)	Nearest Railway Station. (4)	Nearest Steamer Station. (5)	Daily cane crushing capacity in tons. (6)	
1 The Vizagapatam Sugar & Refinery, Ltd., Anakapalle.	Anakapalle. Tel: 'Sugars'.	Visakhapatnam.	Anakapalle M. & S.M. Rly.	Visakha-patnam.	250	DS
M/A Messrs. Kantilal & Seth, Ltd., 14, New Queen Road, Bombay.	Anakapalle ..	..	..	..	..	..
2 Etikoppaka Sugar Factory, M/A The Etikoppaka Co-operative Agricultural and Industrial Society, Ltd. (Tel: 'Sugar Factory', Etikoppaka (via.) Narasapatnam Road.)	Etikoppaka ..	Visakhapatnam.	Narasapatnam Road, M. & S.M. Rly.	Do.	75	DS
3 The Sri Rama Sugar Mills, Ltd., Proprietors Raja of Bobbili, Raja of Venkatagiri and others, Bobbili. (Tel: 'Sugar', Bobbili).	Bobbili ..	Do.	Bobbili, B.N. Rly.	Do.	450 ÷ 150	DS
4 The Sri Rama Sugar Mills, Ltd., Seethanagaram.	Seethanagaram.	Do.	Seethanagaram, B.N. Rly.	..	300	DS
5 The K.C.P., Ltd., Proprietors of Vuyyur Sugar Factory. (Tel: 'Krishna', Vuyyur.)	Vuyyuru ..	Krishna ..	Bezwada, M. & S.M. Rly.	..	850/1000 No jaggery making in the tract.	DS
6 * The Kirlampudi Sugar Mills, Ltd., M/A K. V. Subbarao & Co., Head Office: 99-A, Armenian St., P.B. No. 1519, Georgetown, Madras. Grams: Mechelec, Madras. Phone: 3006 Madras.	Pithapuram ..	East Godavari.	Pithapuram, M. & S.M. Rly.	Kakinada ..	450	DS
7 * The Deccan Sugar & Abkari Co. (Tel: 'Deccan', Samalkota.)	Samalkota ..	Do.	Samalkota, M. & S.M. Rly.	..	500 + 40	(Cane) (Gur) Bonechar.
8 * Messrs. Godavari Sugars & Refiners, Ltd., M/A Messrs. AIDCO, Ltd., Loane Square, Hakim Mansions, Georgetown, Madras, Grams: Ferage, Madras, Phone No: Madras 3006.	Tanuku ..	West Godavari.	Tanuku, M. & S. M. Rly.	..	200*	DS. Not yet ready.

9 * The East India Distilleries and Sugar Factories, Ltd., M/A Parry & Co., Ltd., P.B. No. 12, Madras. Grams: Parry, Madras. Phone No: Madras 2983.	Nellikuppam (Tel: 'Distimule', Nellikuppam).	South Arcot ..	Nellikuppam, S.I. Rly.	Cuddalore ..	2200*	DS
10 * The India Sugars and Refineries, Ltd., Tel: 'Sugars', Hospet.	Hospet ..	Bellary ..	Hospet, M. & S.M. Rly.	..	600	DS
11 The Coimbatore Agro Industries, Ltd., Messrs. V. C. Vellingiri Gounder & Co.	Podanur ..	Coimbatore ..	Podanur, S.I. Rly.	..	50*	Not working in 1949–50.
12 † The Murugappa Sugar Co., Ltd., Mailpatti (North Arcot).	Mailpatti ..	North Arcot ..	Mailpatti, M. & S.M. Rly.	Madras ..	Cane 75	S
13 * The Deccan Sugar & Abkari Co., Ltd., Pugalur Sugar Factory, M/A Parry & Co., Ltd., P.B. No. 12, Madras. Grams: Parry, Madras. Phone: Madras 2983.	Pugalur Sugar Factory P.O. (Tel: 'Desuabeo', Pugalur).	Tiruchirappalli.	Pugalur, S.I. Rly.	..	700	S
14 The Andhra Sugar, Ltd., M/A Ranga Rao & Co., Tanuku, West Godavari district.	Tanuku ..	West Godavari.	Tanuku, M. & S. M. Rly.	Madras ..	600	DC (Not yet ready).
15 * The Madura Sugars and Allied Products, Ltd. Tel: 'Sweet', Ammayanayakanur, M/A Pandia Rajan & Co., Ltd., Ammayanayakanur P.O.	Pandiarajapuram.	Madurai ..	Kodaikanal Road, S.I. Rly.	..	317	S

Explanation.—Mills marked with (*) are members of the Indian Sugar Mills Association.
Mark (†) in last but column denotes Mills which also got gur-refinery plants.
'S' = Sulphitation DS = Double sulphitation. 'C' = Carbonation.
'DC' = Double carbonation.

Area under sugarcane in the different districts of Madras State, with average yields during 1949–50.

Name of the district.	Area in acres.	Average yield of cane in tons per acre.
1 Srikakulam	10,350	27·41
2 Visakhapatnam	25,570	25·96
3 East Godavari	14,000	28·58
4 West Godavari	6,500	25·18
5 Krishna	4,700	29·01
6 Guntur	160	29·38
7 Kurnool	140	19·14
8 Bellary	8,140	23·70
9 Anantapur	5,120	21·21
10 Cuddapah	330	25·45
11 Nellore	20	20·00
12 Chingleput	170	24·53
13 South Arcot	18,320	27·14
14 Chittoor	13,060	20·92
15 North Arcot	12,460	20·10
16 Salem	9,070	23·75
17 Coimbatore	15,460	27·14
18 Tiruchirappalli	14,210	20·87
19 Tanjore	1,110	24·07
20 Madurai	6,000	26·29
21 Ramanathapuram	1,000	16·13
22 Tirunelveli	200	24·55
23 Malabar	220	24·73
24 South Kanara	6,010	25·46
25 The Nilgiris	10	..
Total for State ..	181,880	25·42

CHAPTER 11.

COTTON.

Importance, zones of production, cultivation and factors affecting —History of varietal introduction and early trials—Evolution of strains—Cambodia cotton—Barbadense cottons—Perennial cotton—Nadam cotton—Karunganni, Cocanadas—Mungari—Westerns, Agronomic trials, on season, spacing, seed rate, irrigation, manuring and soil culture—Rotation—Sorghum effect—Mixed cropping—Fundamental research, development studies—Genetics—Fibre technology—Harvesting and yields—Ginning and storage—Seed multiplication and distribution, the several schemes—The Cotton Committees, Central and State—Legislation—Pests and Diseases Act—Cotton Transport Act—The Ginning and Processing Factories Act—The Commercial Crops Act—The Madras Cotton Control Act—Cotton Price Control—Cotton Trade Census Act—Possibilities of future extension of area, short and long-term proposals—List of strains in Madras with characteristics.

PRODUCTION AND IMPORTANCE.

The cotton crop occupies a premier place in the agricultural and industrial economy of the Madras State. Today Madras has a well established textile industry equipped with sixteen lakh spindles and a production capacity of two hundred and twenty-five million pounds of yarn, and one hundred to one hundred and twenty-five million yards of cloth every year. All the raw cotton needed by the mills is being met from local growths supplemented by extra-provincial growths and foreign imports. Further, the entire production of cotton seed after meeting the requirements for planting purposes is utilized as stock feed for the twenty-two million heads of cattle in the State. Madras accounts for roughly twelve per cent of the total area under cotton in the Indian Union and contributes about fourteen per cent to its total production. The estimated annual acreage and production of the different Indian States are furnished in Statement 1, appended.

The estimates for normal area and production for Madras stood at 24 lakhs acres, 5·5 lakhs bales of lint and 2 lakhs tons of cotton seed in pre-war years, while the post-war figures have been fluctuating round about sixteen lakhs acres, 3·5 lakhs bales and 1·2 lakhs tons of cotton seeds. An analysis of the area estimates for the past thirty years shows a downward trend after 1937–38, the extent of fall being 8·75 lakhs acres or roughly 30 per cent in 1948–49.

Area under cotton in Madras (000's acres).

Years.	Irrigated.	Unirrigated.	Total.
1918 to 1923	160	2,340	2,500
1923 to 1928	220	2,465	2,685
1928 to 1933	196	2,031	2,227
1937 to 1938	274	2,157	2,431
1942 to 1943	258	1,999	2,257
1947 to 1948	209	1,510	1,719
1948 to 1949	162	1,394	1,556

The chief causes of such a decline since 1937–38 are traceable to the State control on cotton prices which were fixed at low levels and differentials to the voluntary switch-over to other cash crops like groundnuts in rain-grown regions, to the diversion on account of special concessions offered in the Grow More Food Campaign to food crops like rice and millets and to the legislative restrictions imposed on the cultivation of cotton.

The commercial crop of Madras comprises of the indigenous and exotic varieties of the cultivated species botanically classified under the genus *Gossypium* (Linn.). Cambodia, an exotic variety belonging to the botanical race of *Gossypium hirsutum* is the long and superior medium staple component popularly known as the American cotton in trade, while the medium and short stapled *desi* consist of nine distinct varieties of the indigenous races of *Gossypium arboreum* and *Gossypium herbaceum*, the latter occupying a secondary place in production. The estimated acreage and production for the year 1948–49 classified by varieties and staple length are given in Statement 2 appended.

After the division of India, Madras, Mysore, the Punjab and Uttar Pradesh are the only zones where American cotton of good quality equivalent to Pakistan styles can be produced in bulk. To make good and the deficit arising out of partition of the country. Madras naturally is called upon to play a vital role in regard to achievement of self-sufficiency not only with regard to her needs but also to increase the output of the longer staple denominations.

A plan drawn up for the production of raw cotton in Madras took into account the population statistics, consumption figures expanding spindlage and export trade, and placed the post-war needs of the State at 4·25 lakhs bales in each of American and *desi* cottons. Madras will, therefore, have to double her total production, increase output of quality American by three lakh bales and convert all short-staple into medium quality cottons, if State self-sufficiency with regard to quality and quantity is to be achieved Concerted efforts towards formulation of ways and means for achieving this end highlight the tempo of cotton research in this State.

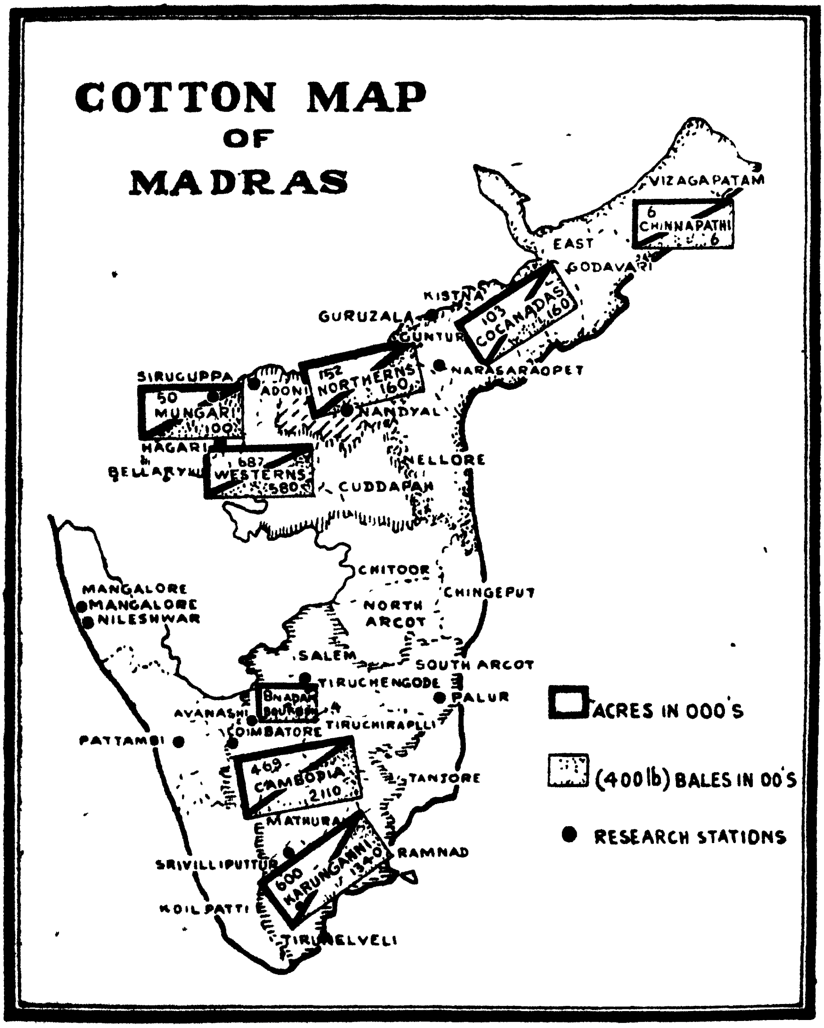

Plate 74.—Cotton map of Madras. P. 483

THE INFLUENCE OF CLIMATE, SOIL AND IRRIGATION ON CROP PERFORMANCE AND CULTIVATION PRACTICES.

Cotton is essentially a tropical crop thriving best under hot and humid climates. It is cultivated in a variety of soils and climatic zones in this State and on account of large variations in soil, rainfall, and irrigation facilities, ten distinct ecological tracts can be distinguished. The cultivation of Cambodia is restricted to red and reddish loams of the central and southern districts receiving an annual precipitation of 20 inches to 40 inches. This variety will admit of division into two major groups based on seasons of planting. The cold weather crop planted in September–October comprises of both irrigated and unirrigated Cambodia while the summer crop is grown entirely under irrigation between the months of March and September in the districts of Ramanathapuram, Madurai, Tirunelveli and South Arcot. The bulk of unirrigated Cambodia sown during the month of December in South Arcot may be grouped under the latter category since the harvest months coincide with that of irrigated summer crop. The crop matures roughly in six to seven months with about 30 acre inches of water. Normal yields of 250 to 300 pounds of lint per acre are registered for the irrigated area while the rainfed crop gives about 100 to 125 pounds of lint.

The entire stretch of the black soil area from Tiruchirappalli to Tirunelveli will represent the '*Tinnies*' cotton tract where 'Karunganni' is grown. It receives an annual rainfall of about 25 to 40 inches and the sowings are usually done in October-November with the break of the north-east monsoon. Except for a very small irrigated area in Madurai and Coimbatore districts, the crop is entirely rainfed. The harvests are completed by April and lint yields of 100 pounds per acre are usually obtained. 'Uppam' is essentially a black soil variety whose acreage of late is dwindling and which is favoured in certain well defined portions of the '*Tinnies*' tract more as a component for mixture than as a pure crop. The main advantage of the mixture lay not in increased seed cotton yields but in reducing the fluctuations arising out of unfavourable seasons through the presence of a large proportion of natural hybrids found in such mixtures. The pure crop of *Uppam* is capable of yielding about 65 pounds of lint per acre in normal seasons.

'*Nadam*' and '*Bourbon*' varieties found on the poor and gravelly soils in Coimbatore and Salem districts and form the principal components of the perennial cottons in Madras. They are usually kept on the ground for three to five seasons and give 20 pounds of lint per acre per season on an average. '*Westerns*' group covers the arid black soil region in the districts of Bellary, Anantapur, Cuddapah and Pattikonda, taluk of Kurnool district, where the annual rainfall is about 20 inches. The soils are mostly

black clay loams known as '*regada*' or '*regur*'. The sowings are done in the late '*hingari*' season during the months of August-September and the harvests usually completed by April, average about 50 pounds lint per acre. This is the only area growing pure *herbaceum* variety in the State.

'*Mungari*' is yet another well-defined category limited in spread to the red and mixed black soils of the Ceded districts. This is an early season crop as the name '*mungari*' signifies and is planted in June-July on receipt of South-West Monsoon rains. It comes to harvest in December-January and yields about 65 pounds lint per acre.

'*Northerns*' tract signifies the rainfed black soil area of Kurnool district not invaded by either '*Westerns*' or '*Cocanada*' groups. The same seasons of planting and harvests found in the '*Westerns*' tract prevail in this zone also. Definite coloured pockets occur in this area. The normal yields are low at 50 pounds lint per acre and are due to a low ginning outturn of 26 per cent.

'*Cocanadas*' is the trade name of the rainfed *desi* cotton cultivated in the long stretch of country from Nallamalai hills in Kurnool district to the southern limits of Visakhapatnam district. A coloured variety which yields normally 75 pounds of lint per acre is sown in this region during July–September and harvested from January to March. A white variety of minor importance is '*Chinnapathi*' whose cultivation is restricted to Visakhapatnam district barring Narasapatam taluk. It is planted in July during *tholakari* season or in December as *buradapathi* cotton and harvested in December and May, respectively. The normal yield is at 50 pounds lint per acre.

VARIETAL INTRODUCTIONS AND TRIALS.

The cultivation of exotic Cambodia in Madras is comparatively recent in origin while the indigenous *desi* varieties have been raised from time immemorial. The initiation and expansion of cotton research by the Madras Agricultural Department is contemporaneous with the successful introduction and acclimatization of American cotton. The earliest historical record pertaining to introduction of American cotton in Madras dates as far back as the year 1790, when Dr. Anderson distributed seeds from Mauritius. The surviving relic of this attempt is '*Bourbon*' cotton now found mixed with perennial '*nadam*' in parts of Coimbatore district. During the years 1800–1819, the East India Company tried exotic varieties in their farms but failed to establish any. Further enterprising efforts of the Company during 1845–1853 also did not yield useful results.

Plate 75.—A bulk crop of Karunganni.

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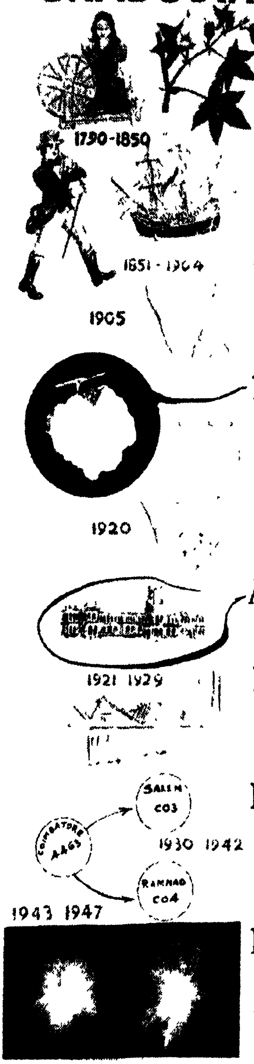
CAMBODIA COTTON IN MADRAS



G. ARBOREUM IS THE NATIVE OF INDIA. DACCA MUSLINS WERE MADE FROM IT.

TRIAL OF AMERICAN COTTONS BY EAST INDIA COMPANY. THE SURVIVING RELICS ARE DHARWAR AMERICAN AND BOURBON VARIETIES.

TRIAL OF *BARBADENSE, RELIGIOSUM AND HIRSUTUM* VARIETIES ON THE GOVERNMENT FARM, SAIDAPET ENDS IN FAILURE.

EXOTIC AMERICAN FROM CAMBODIA IN INDO CHINA TRIED BY STEELE UNDER IRRIGATION RESPONDS WELL AT VIRUDUPATTI.

EXTENSION OF CULTIVATION TO COIMBATORE, SALEM, MADURA AND TRICHINOPOLY DISTRICTS.

APPOINTMENT OF A WHOLE TIME COTTON SPECIALIST TO IMPROVE THE CAMBODIA COTTON.

EVOLUTION OF STRAIN CO2 EXTENSION OF CULTIVATION TO UNIRRIGATED TRACTS. EXPANSION OF COTTON MILLS AT COIMBATORE.

RELEASE OF THREE HYBRID STRAINS CO3 IN SALEM, CO4 IN RAMNAD, 4463 IN COIMBATORE MADRAS SUCCEEDS FOR THE FIRST TIME IN PRODUCING LONG STAPLE COTTON OVER ONE INCH.

ISOLATION OF INTERSPECIFIC HYBRIDS 7682 & 7733 HAVING 1⅛ TO 1 3/16 STAPLE DECLARED EQUAL TO IMPORTED EAST AFRICAN STYLES

Plate 76.

In the Saidapet College Farm, the *New Orleans*, *Sea Island*, *Upland American* and *Brazilian* varieties were tried during the years 1878–1890. But all of them failed due to insect damage by *jassids* (*Empoasca Spp.*) In 1905 the trial of American, Peruvian, Egyptian, Sea Island and Caravonica cottons in the Government farms of the Agricultural Department at Hagari, Attur, Taliparamba and Kovilpatti did not result in any success. During 1906, Cambodia cotton *kapas* was found as a mixture in bales of lint imported at Pondicherry. It was first brought to Tirunelveli by one Mr. Benson who obtained the seeds from the President of the Chamber of Commerce, Pondicherry. This cotton takes its name after the place Cambodia in Indo-China from where it was originally obtained. The first trial as an unirrigated crop on the black soils proved a failure but in the succeeding year its high potentialities for yield under irrigation was discovered by Mr. Steel of Harvey and Company, Virudunagar. All the indigenous cottons cultivated during that period were rainfed. The successful trial of Cambodia at Virudunagar under irrigation stimulated the ryots to take to its cultivation with a certain measure of avidity. The variety came to stay as an outstanding example of successful introduction and acclimatization of American cotton in South India since the subsequent extension of acreage was rather spontaneous and reached the figure of 305,000 acres in 1920 with the assistance rendered by the Agricultural Department. Complaints were heard about the deterioration of this cotton in the meantime and an All-India Cotton Committee (1917–1919) constituted under the chairmanship of Mr. Mackenna recommended the appointment of a wholetime Cotton Specialist to take up improvement work on Cambodia cotton and also render technical advice to the regional Deputy Directors of Agriculture who were dealing with the indigenous cottons in the different research stations. Breeding material was secured from Cochin-China and work was commenced in 1919. A wholetime Cotton Specialist was appointed in 1920 and a Cotton Breeding Station at Coimbatore was established. The progress of research at this centre and at the different regional research stations are summarised elsewhere.

The introduction and trial of the Sea Island cottons were also done somewhat on similar lines. The history of efforts made by several institutions and agents to acclimatize the *barbadense* group of cotton in various parts of India is a picture of total failure and of negative value except in Mysore, where Egyptian varieties are reported to grow successfully under irrigated and well manured condition in small experimental plots. The earliest attempt in Madras refers to the unsuccessful trial of Sea Island cotton obtained from Georgia in 1831 as a raingrown crop in the districts of Cuddapah, Guntur, South Arcot, Salem and Coimbatore. Subsequent experiments conducted under the aegis of the Madras Agricultural Department at Attur and Saidapet farms were given up as unfruitful. Interest in this cotton was again revived in

1930 when exploratory trials were conducted at the Agricultural Research Stations in Malabar and South Kanara districts with Sea Island and Egyptian varieties as rain-grown crop. The performance was generally poor. '*Ashmouni*', an Egyptian variety recorded the maximum yield of 75 pounds of seed cotton per acre. All varieties failed to withstand the rigours of summer and the damage by boll-worm (*Platyedra gossypiella*) was noticed to be considerable. During this period, a gentleman farmer secured seeds of *Montserrat* and *St. Vincent* varieties through the good offices of the Secretary, Indian Central Cotton Committee and the Cotton Specialist, Coimbatore. The area did not extend beyond the confines of his homestead. The question of cotton cultivation in South Kanara was re-opened in the year 1947. The inspection of the standing crop in the bungalow compound of the gentleman farmer at Udipi, disclosed that the growth, yield, opening of bolls, and quality of harvest were satisfactory. The variety could stand pruning and retention for over seven years and could tolerate shade without any attendant ill effects. Exploratory trials were therefore planned in 1948 and incorporated in the scheme of experiments on Sea Island cotton in West Coast financed by the Indian Central Cotton Committee, since 1949. Experiments are under way to utilize the triennial fallows on two lakh acres of *modan* lands in Malabar, to intercrop four lakh acres of coconuts in Malabar and South Canara, and to crop 65,000 acres of *Kumeri* lands in South Kanara, with cotton.

The introduction and trial of Cambodia cotton in the deltaic areas of Tanjore, Krishna and Godavari, with a view to fit in the same as an off-seasonal crop in rice fallows mark new attempts at cotton expansion Experiments on cotton growing at the Agricultural Research Station, Maruteru, were conducted for the first time in 1930–31. The results gave indications of the possibility of growing Cambodia in the heavy delta soils of the Godavari and Krishna districts as a second crop after rice and after a *punasa* or early crop in the high level irrigable lands bordering the delta and in the *lanka* soils, in rotation with chillies, tobacco, etc. Yields averaged 600 pounds of seed cotton per acre. A summary of the earlier trials at the Agricultural Research Station, Aduthurai, in Tanjore delta during 1934–39 showed that cotton could be fitted in the single crop rice lands without affecting the yield of succeeding rice. The crop planted in January–February gave good quality cotton up to 500 pounds seed cotton per acre by end of September. Trials have been under way since 1948 in the Agricultural Research Stations at Aduthurai and Pattukkottai and in ryots' holdings in the Tanjore delta to develop a variety with a five-month duration so as to suit both single and double crop wet lands. The preliminary data are very encouraging and promise to yield types capable of completing harvests by end of June and of recording over 1,000 lb. of seed cotton per acre.

Trials of perennial types belonging to *Gossypium hirsutum* and *Gossypium barbadense* from South America at the Cotton Breeding station indicated the suitability of *Moco* and *Quebradinho* for homestead and backyard cultivation. The seeds were distributed for extensive trials in all the Agricultural Research Stations as also to enterprising gentlemen farmers throughout the State. Reports about performance are very encouraging from all over the State. *Moco* is reported to be doing extremely well on cultivable wastes in North Malabar. It has a great future for cultivation in backyards, canal bunds and waste lands and intercropping coconut, pepper, arecanut and fruit gardens.

Waves of collection of *hirsutums* from America, Russia and Africa and *barbadense* from Egypt and West Indies have been made from time to time ever since hybridization experiments were taken up by the cotton researchers in the early thirties. Almost the entire range of cultivated ecotypes in the four species *G. hirsutum*, *G. barbadense*, *G. arboreum*, and *G. herbaceum* and many of the wild species of the genus are maintained at the Cotton Breeding Station, Coimbatore. A regular study of crop systematics has been in progress and based on the extensive knowledge gained thereon planned hybridization is being carried out.

EVOLUTION OF STRAINS.

The major portion of cotton improvement work in Madras falls under this head. The cotton industry of the State suffered from three main defects, viz., low acre yields, poor quality and high cost of production compared to other major cotton growing countries. The cultivation was sought to be rendered more remunerative through evolution of races which would in a very large measure offset the disadvantages enumerated above. The basic policy in breeding has been quality improvement aiming at the conversion of short and medium-short indigenous types to medium staple group of 7/8 inches, and of exotic cottons to long staple forms exceeding full one inch. Concurrent with this work, experiments to increase production in general are conducted to cover improvements in yield per acre, ginning outturn and minimising crop loss arising out of incidence of pests, diseases and adverse environment. The items of research pertain to all the nine different varieties of cotton grown in the several ecological zones of the State. The permanent Agricultural Research Stations or the temporary leased farms located in the respective cotton zones constitute the centres of research for each tract. Breeding programmes and problems of agronomy pertaining to the specific needs of each tract receive attention at these research centres. The breeding methods adopted are on up-to-date lines governed by established genetic concepts involving the use of biometry for the proper interpretation of the results.

Cambodia cotton.—Pure line work on this variety was started at the Cotton Breeding Station, Coimbatore, in the year 1920 and the first fruits of selection were two strains, viz., Co. 1 and Co. 2.

The latter proved to be a hardy, vigorous, productive and quality strain. It was also found suitable for cultivation as an unirrigated crop in red soils receiving adequate rains. Its release in 1929 helped considerably the extension of cultivation to new tracts and added to the profits of the farmers both on account of increased yield per acre and better quality of lint. Its staple length of seven-eighth inch was about the best available in Madras at that period and the variety formed the mainstay of the expanding mill industry of southern districts for spinning counts of 20's and over.

The taste of the consumers in the matter of manufactured textile goods was undergoing a steady change towards finer cloth and the varieties grown in India were unsuited for spinning counts of yarn higher than 40's. This meant that we should continue to import either finer yarn and piece-goods or long staple raw cotton needed by the mills. Both these steps would adversely affect the monetary resources of the country and would reduce us to a state of dependency on foreign countries for regular supplies. It was therefore thought imperative that Madras should look ahead and concentrate her efforts on the evolution of staple cotton equivalent to the foreign imports.

A very large number of varieties from countries like America, Africa and Russia was obtained, studied and crossed since the year 1932. Early success was obtained in crosses involving local strain, Cambodia 2 and South African varieties from Uganda. The hybrid strains 4463, *Cambodia* 3 and *Cambodia* 4 registered remarkable improvements in habit and quality. The growth period of Cambodia which was roughly seven months was brought down to six months, and the staple length was advanced by about ⅛ inch. These changes were reflected in the agronomy of the cotton tracts. The Coimbatore taluk which adhered to the intensive cropping of sorghum-cotton preferred to grow 4463 in place of Cambodia 2. The water stress, open soils and poor quality of cotton in Salem district improved under a switch over to the new early maturing strain *Cambodia* 3, both as irrigated and as a rainfed crop to the exclusion of other indigenous varieties. The release of *Cambodia* 4 marked a milestone in the progress of cotton improvement in Madras on account of its spread as an off-seasonal crop in tankfed rice lands of the southern districts in summer months. All the three new strains represented cottons, which could be classed equal to some of the imported styles and of these *Cambodia* 4 by virtue of the season of its growth would fall under 1-1/16 inch staple, like the bulk of the East African varieties. In addition to the crosses made between similar varieties, species hybrids using Sea Island and Egyptian Cottons were also attempted. In slow stages two strains, viz., 7682 and 7733 were evolved but they lacked the requisite vigour and adaptability of the local varieties.

A cotton picture of 1943 showed that the various improved strains recommended for cultivation in distinct ecological zones

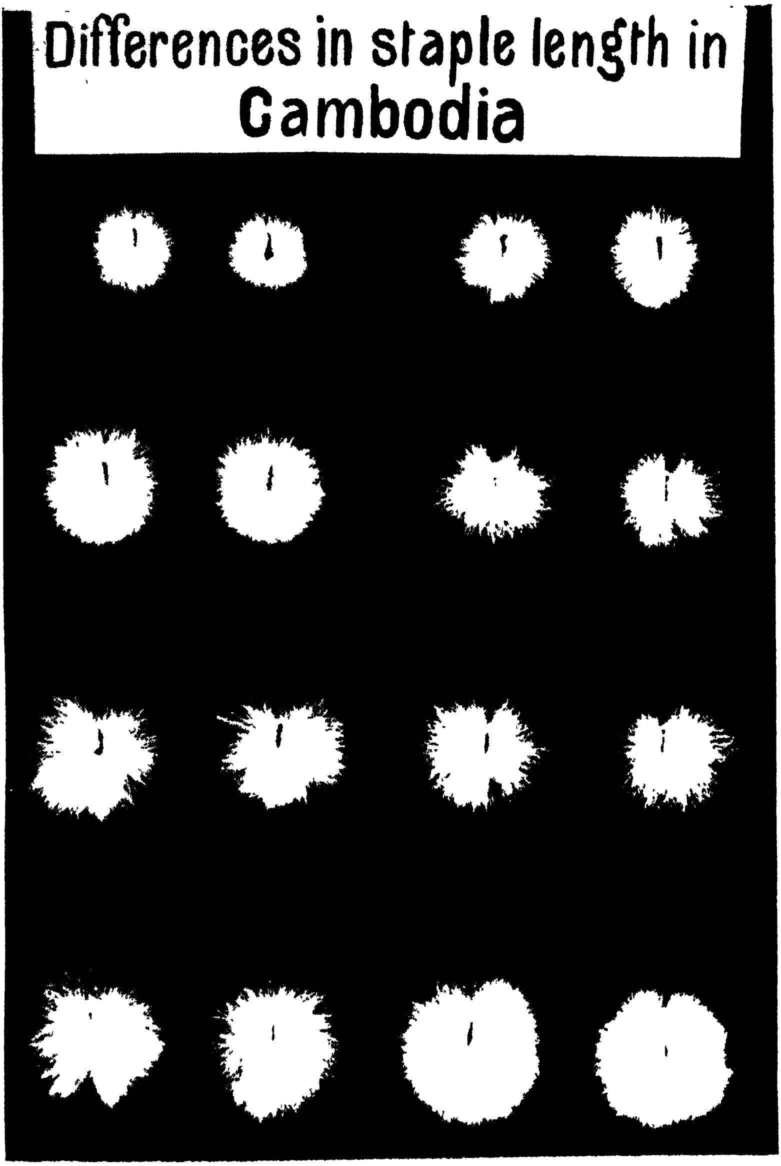


Plate 77.

enjoyed only limited spread and popularity and came up to the staple length standards ranging from 28/32 to 31/32 inch with the exception of *Cambodia* 4 which touched the 1-1/16 inch mark. Among the varieties, *Cambodia* 2 covered the largest area as irrigated and raingrown winter crop 4463 remained localized in the early sown portions of Coimbatore taluk; 920 found favour in Coimbatore district but suffered from 'blackarm' disease in wet seasons, *Cambodia* 3 proved to be susceptible to angular leaf spot; and *Cambodia* 4 was very popular in the summer area but lacked the resistance to bacterial blight. Consequently a multiplicity of varieties studded the area.

In cotton, as in most commercial crops, the aim of the breeder should be the evolution of varieties suited to greater environmental diversity in order that the quality stipulations of the end product might conform to the limited range permitted in trade. *Co. 4/B* 40 (recently christened as *Madras Uganda* 1) was obtained as a reselection from parent stock of *Cambodia* 4. The performance of the substrain on a wide range of environmental conditions covering the whole of the red soil tract adopting different crop sequences and planting dates was studied in several regional trials. It could yield as much as the local varieties in seed cotton while the ginning outturn was same. It required one irrigation less and evaded drought by early maturity. It was tolerant to *blackarm* to which the existing strains, *Cambodia* 2, *Cambodia* 3, *Cambodia* 4 and 920 were susceptible and its staple length was a definite improvement over Co. 2 and 920 which occupied the bulk of the winter planted area. Being a cosmopolitan strain, the main advantage of the unification of the winter and summer areas would be the ease in maintaining purity and the production of large quantities of quality cotton. *Madras Uganda* 1 might therefore be classed as a new cosmopolitan strain having a consistent record in winter and summer as well as under irrigated and rainfed conditions.

Hitherto the long staple work was confined to summer season, but the study of several new hybrids at Coimbatore showed that synthesis of staple lengths over 1-1/8 inch was possible in the cold weather crop also. Five hybrid derivatives 9,030, 0811, 0744, 9708 and 019 were outstanding in all attributes. Ginning increase of two per cent equivalent to six per cent of seed cotton yields, and record fibre length of 1·21 inches for winter Cambodia and American Upland in India have been registered. Regional trials, for testing some of these promising biotypes, are under way.

Breeding work for long staple varieties especially over 1-1/16 inch, is possible only at three places in the sub-continent, viz., Sind, Punjab and Madras. A limited amount of breeding was done in the summer season at Srivilliputtur in Ramanathapuram district under the auspices of the State Government prior to the sanctioning of a scheme, by the Indian Central Cotton Committee, which commenced to function in November 1946 at the Agricultural

Research Station, Palur, in South Arcot district. The venue of trials has since been shifted to Srivilliputtur retaining Palur as a sub-station on account of defects noticed in flowers and seeds of the cotton crop. The objects of the scheme are the isolation of Upland strains longer than 1-1/16 inch staple and capable of maturing in five and a half months and the evolution of *barbadense* varieties equivalent to the average Egyptian Styles suitable for cultivation in the coastal belts of South Arcot district.

Acclimatization of long staple Upland varieties collected from all parts of the world was not helpful. As hybridization on a fairly intensive scale had already been started before the scheme was put into operation, the material comprising of intervarietal and interspecific crosses in various generations, formed the nucleus for further breeding work. Among them three interspecific biotypes, viz., 7682, 7727 and 7733 constituted the best parents for the synthesis of staple length combinations. 7682 exceeded control *Uganda* 1 in yield trials and maintained superiority in staple length and spinning value. It was earlier than *Uganda* 1 by ten days and exceeded the 1-1/16 inch staple limit, set as the primary objective of the breeding scheme. It is therefore being employed as the new control in all small and large bulk trials conducted on the station and the cultivators' lands. A general survey of the material handled in the inter-varietal long staple *hirsutums* indicated that reduction in crop life by about ten days, improvement in staple by 1/16 inch, increase in ginning by 2 per cent and an yield of 400 pounds *lint* per acre were feasible items.

Ceded districts are subjected to frequent visitations of famine on account of uncertain and uneven distribution of rains. The waters of Tungabhadra river are being harnessed for irrigating about a million acres in both Madras and Hyderabad, and irrigated cotton figures as a major crop for cultivation in the project. It is proposed to align the irrigated area on the basis of "*Kharif*" and "*rabi*" seasons and to allow water in regular turns of once a fortnight during four months, viz., June to September for "*kharif*" and October to January for "*rabi*" in each year. Varietal trials conducted with cotton on the Agricultural Research Station, Siruguppa, since its inception in 1937 on irrigated heavy black soil, showed, that the American varieties when sown as "*kharif*" crop was subjected to red-leaf, later maturity and low yields. They could, however, be successfully cultivated as a "*rabi*" crop, if the planting time was shifted to middle of August. A variety, Hyderabad American II, proved to be the most consistent in yield and quality. The alteration of the sowing date to a period in "*kharif*" will be a feasible proposition since more than two waterings will not be required till the end of September to supplement the normal rains. The problem is, therefore, one of breeding a biotype which, when planted in August-September with irrigation, nursed by rains till October and helped to maturity with fortnightly irrigations till the

end of January, will prove to be a remunerative crop. Breeding work on the American cotton was, therefore, started in 1943 as part of a scheme financed by the Indian Central Cotton Committee. The trials are now conducted at Siruguppa, Hagari and Nandyal so as to enlarge the scope of the work to distinct regions, viz., irrigated black soil, unirrigated black soil subject to variable rainfall and unirrigated black soil characterized by early season and heavier rainfall respectively. Collections from India, Indo-China, Iraq, Persia, America, Africa and Russia were tried under irrigation at Siruguppa and under unirrigated conditions at Hagari and Nandyal. Of the varieties tried Dharwar-American was the best from the point of response to black soil irrigation and resistance to drought under unirrigated conditions, while the Coimbatore types invariably maintained their staple length. The results of further breeding research carried out indicated that strain MA 2 was the best for early habit, yield and jassid-resistance and Surat back crosses were good for quality. All the varieties responded to re-selection and MA 2 and G 1 × Co. 2–5 imparted most of their good attributes to their hybrids. Five re-selections, viz., 83, 1908, 1227-1, 1635-4 and 1712 were superior to *HA* 11 in yield. Further work is in progress. An interesting, but nonetheless consistent, observation made on the irrigated cotton raised on the black soils of Siruguppa was that the lint maturity was very low and that in spite of such a drawback, strain *HA* 11 recorded spinning value of 40's warp. The same types when raised entirely as rain grown crop possessed higher maturity.

In the trials with rain-grown American, the trends were in favour of types from Dharwar, Mysore and Surat. It was sought to find out whether it would be possible to select a cosmopolitan type having higher flexibility of response under varied soil and climatic conditions. It was gratifying to note that the derivatives of *MA* 2 and *GI* × *CO*. 2–5 which were found to be the best under irrigation were equally good for the unirrigated tract. The ideal of a common variety for the Ceded districts appear to be an eventual possibility. So the possibilities of replacing the *desi* types grown in this tract by a suitable variety of American cotton, on the analogy of other countries, like U.S.S.R., China and Persia are great. The successful cultivation of Dharwar-American cotton by farmers themselves in certain parts of the Ceded districts is a definite pointer to the soundness of the attempt.

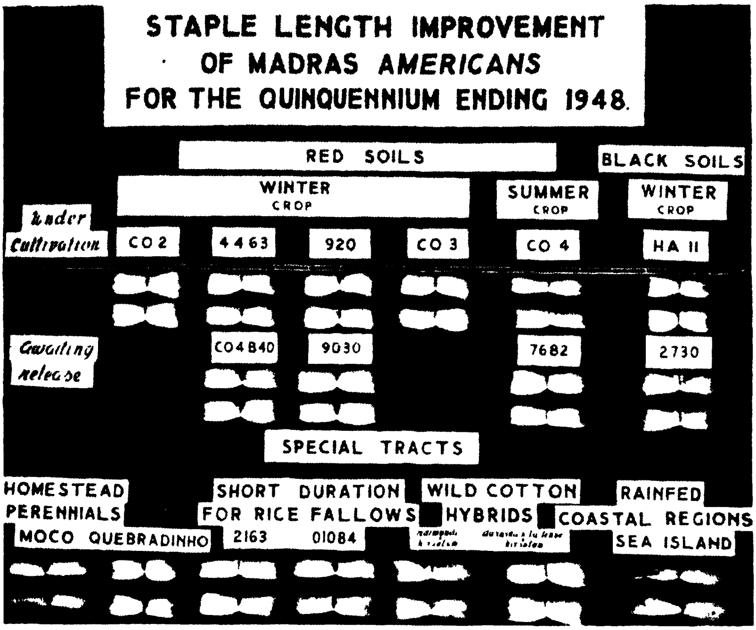
The area under rain-grown American cotton in the State is more than half the total American. The defects noticed in them are low cropping capacity, large fluctuations in yield, and poor staple and maturity. The objects of breeding are therefore improvements in quality and yield by selection of a hardy biotype capable of withstanding the rigours of climate in the southern regions instead of depending on the spread of winter varieties bred under irrigation at Coimbatore. A wide range of variable material was subjected to selection for the ability to withstand drought

either by early maturing habit or through normal growth under low-levels of soil moisture at reproductive phase. The best of them were X 82, G 1 × CO. 2, MA. 2, SB. 115 and SB. 91. The limited work carried on at Coimbatore so far has not been encouraging as the place is unsuited for such breeding trials. The work has been shifted to Periyakulam in Madurai district under a new scheme sanctioned by the Indian Central Cotton Committee and put into effect from 1950.

There is immense scope for developing the rice regions of Tanjore and Godavari deltas by fitting in Cambodia cotton as an off-seasonal irrigated crop between two rice crops on single and even double-crop wet lands wherever supplementary irrigation from wells are feasible. The limiting factors in these regions are atmospheric temperature at flowering phase and rainy weather at harvest stages. The successful utilization of rice fallows therefore depends upon the evolution of short duration varieties having a total crop life of 170 days from planting to uprooting since the main factor is duration and not water. All areas where rice harvest is completed by the end of December or early in January may lend themselves for such cultivation. The problem was therefore taken up in 1948 and tackled from the angle of varieties and planting dates. The crop at the Agricultural Research Station, Pattukottai was fair in growth and could be accelerated further in initial stages by planting on ridges and application of nitrogenous manures. Punjab, American and East African varieties were the earliest of the collections, some of them recording as much as 1,000 pounds of seed cotton per acre before end of June. Exploratory trials with short duration *desi* cotton similar to *buradapathi* of Visakhapatnam conducted in the year 1950 as an unirrigated off-seasonal crop in old and new delta, were not encouraging.

A survey of quality improvement in Madras Cambodia reveals remarkable improvements in staple. The sorter lengths, maturity values and mean fibre weights registered substantial increases over the existing strains, Pakistan varieties and East African styles. The mean value of 1·21 inches by Balls sorter is a new record for winter Cambodia in Madras and American Upland in India. The extent of improvement could be gauged from the spinning reports which placed suitability of some of the new derivatives at 58's against 35's of Cambodia 2.

The Madras American strains under distribution are quite popular in the Cambodia tract. *Cambodia* 2 is sought after in the major portions of irrigated and unirrigated regions having been aided in its rapid progress by the seed distribution scheme working at Tiruppur. 4463 and 920 enjoy a limited amount of popularity in early sown portions of Coimbatore taluk, and *Madras Uganda* 1 is fast replacing these varieties of late. *Cambodia* 3 has almost displaced irrigated *Cambodia* 2 in Salem district and an area of 31,000 acres is estimated to be covered at the closure of the seed scheme.



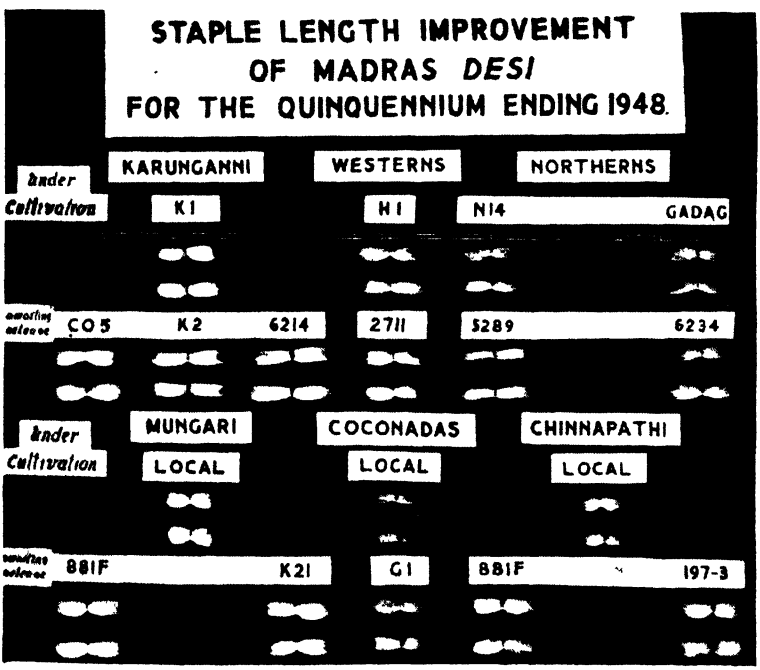


Plate 78. P. 499

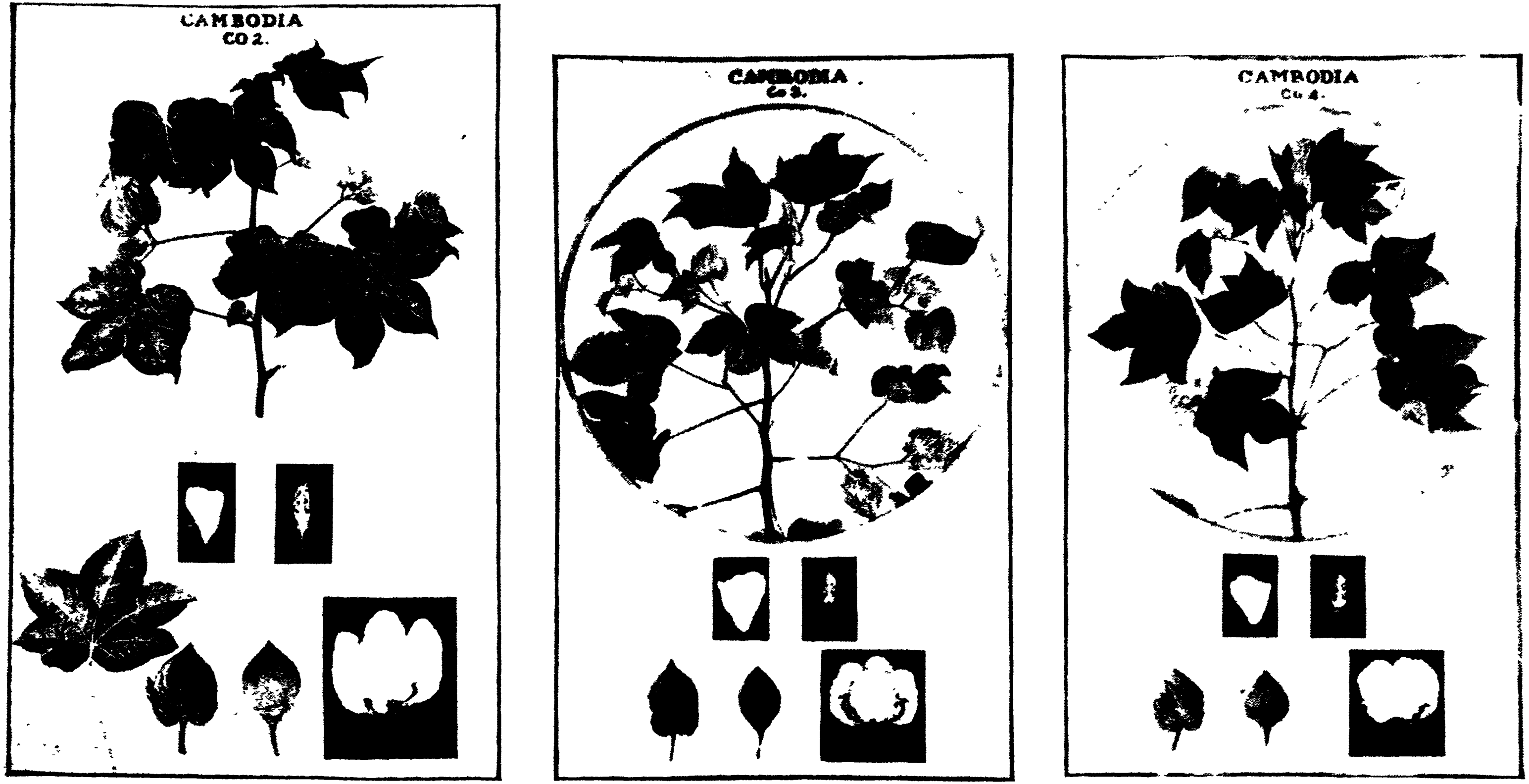


Plate 79.—Cambodia strains.

run for multiplication and distribution. *Uganda* 1 has practically ousted all other types from the summer planted area. The area of spread of all the improved Cambodia strains during the year 1948–49 was 1·68 lakh acres covering 65 per cent of the total area under irrigated and rain-grown American in the State. The chief distinguishing features of the improved strains *Cambodia* 2, *Combodia* 3, and *Uganda* 1 are furnished in Statement 3 appended.

G. barbadense cottons.—The Madras Long Staple Cotton Scheme financed by the Indian Central Cotton Committee, which started functioning in 1946 has for its objects the evolution of *barbadense* varieties equivalent to the average Egyptian Style, suitable for cultivation in the coastal belts of South Arcot district, in addition to the isolation of long staple Upland strains for the summer area. Study of world collection of *barbadense* varieties from West Indies, Egypt, Anglo-Egyptian Sudan and South America at the Agricultural Research Station, Palur, disclosed the following features. The types were slow to grow up to June and thereafter the growth-rate was rapid. The high humidity and intermittant rains of July were congenial for the development of blackarm and the method of secondary infection through periodical sprays of bacterial inoculum, brought out the resistant group prominently, while all others suffered from severe leaf fall. Among them, 1730, *Bar* 4/11 and *Bar* 4/15 from Anglo-Egyptian Sudan proved to be highly resistant though shy in yield. The Egyptian varieties especially *Giza* 7, 12, 36 and *Maraad* were the best among the whole set in general bearing. The mean value of halo length for the *barbadense* varieties ranged from 30 to 33 m.m. The fibres were silky fine and strong. Possibly the *barbadense* varieties would do better if planted in August-September before the outbreak of north-east monsoon since they require humid conditions during growth and cooler temperature at ripening phase. Planting trials are under way.

West Indies and West Coast (Madras) are so similar in soil types, rainfall intensity and atmospheric humidity that it should be possible to fit in the *Sea Island* cotton, the main commercial crop in West Indies. Sea Island varieties like *Montserrat* and *St. Vincent* from West Indies, select *barbadense* strains from Egypt, acclimatised types like *Udipi*, *Almora* and synthetic hybrids like *Kidney Sea Island* cross were sown in May 1948 at Pattambi, Nileshwar and Mangalore. The Sea Island types especially *Udipi* made good growth and were in bearing by October. They responded to ratooning and stood the shade under coconut trees. The quality of produce was as good as *Montserrat* style with a mean staple of one and a half inches. Further work was initiated in 1949 as part of a scheme financed by the Indian Central Cotton Committee. During the first year several varieties including *St. Vincent*, *Montserrat* and long staple Egyptians were tried in *modan* and *bettu* lands as pure crop and in coconut plantations as intercrop. The pure crop at Pattambi and Mangalore was more or

less a total failure despite good growth. The poor yields are attributable entirely to the very severe attack of black-arm aggravated by the incessant downpour during an abnormal and early South-west Monsoon. In contrast to these, the crop grown under the coconuts was well grown, profuse in flowering fairly productive and comparatively free from disease, bearing on an average 12 good bolls. The yields of seed cotton ranged from 126 to 360 pounds per acre in individual plots. The quality was better in all respects than the crop harvested in the open. Mean length of 1·60 to 1·65 inches was registered. Among the several varieties tried, Sea Island types *St. Vincent* and *Montserrat* were the best, while all other long staple Egyptians were poor. Single plant selections were therefore made in these two types for productivity in field and for high ginning in the laboratory. Further trials towards selection of types resistant to blackarm, comparison of fresh arrivals from abroad and study of interspecific and intervarietal hybrids between Sea Island and Egyptian cottons on the one hand and *Moco* and *Quebradinho*, two perennial varieties, on the other, are in progress.

Perennial cotton.—In order to supplement the short production of raw cotton required for both mills and hand spinning, the trials with perennial varieties belonging to *G. hirsutum* and *G. barbadense* were undertaken. The experiments were initiated with the objects of replacing the existing perennials like *nadam*, *podupathi* and *dev-kapas* found in cultivation as isolated bushes and fitting in the best of them in house compounds, hedges, bunds along water course, waste lands and cashew fruit or coconut gardens. After preliminary trials at Coimbatore, five South American varieties were distributed in the year 1947 to the several Agricultural Research Stations all over the State covering a wide range of soil and climatic conditions. Of these, *Moco* and *Quebradinho* have done well. They exhibited periodicities in flowering, giving two harvests per year, stood pruning remarkably well and were least subject to pest damage. *Moco* has a staple length exceeding one inch and is fine. It will supply the long felt want of a fine variety for higher counts in hand spinning. Six new Brazilian types, *Moco 1*, *Moco 2*, *Moco madeira branca*, *Caramura 2*, *Rim de Boi* and *Verdao* and two other Yunan types, viz., *Kaiyuan* and *Wenshan* were added to the perennial collection in 1949. Some of these might suit the denuded forest lands which are located in unhealthy regions, where human and cattle labour is scarce and costly. Third year ratoons have recorded as much as 4·5 lb. seed cotton per bush. *Moco* has stood submersion for a week in North Malabar and is putting on good growth on poor shallow soils of North Malabar. It promises to prove a suitable waste land cotton.

Nadam unirrigated.—On the poor light red soils of Coimbatore and Salem districts, a short and coarse linted variety *nadam* (*G. arboreum* race *indicum*) is being raised as a parennial crop for four or five years. This practice is conducive to the uninterrupted

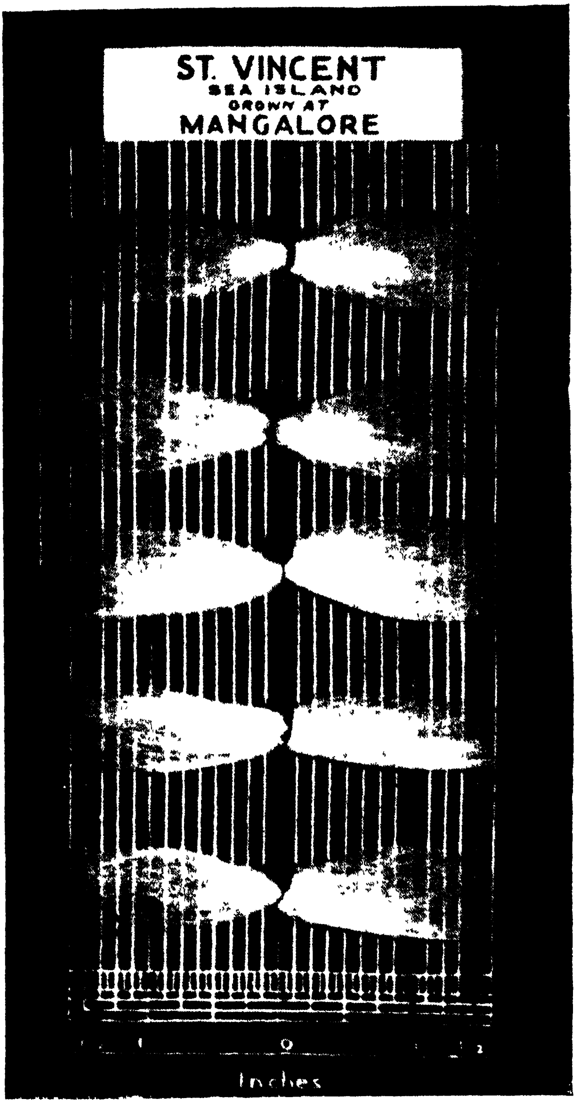


Plate 80—*Sea-Island Cotton.* P. 503

Plate 81.—*Perennial Moco.* P. 504

breeding of the insect pests like cotton stem-weevil and boll worms. The damage done by these insects to American cottons grown in the neighbourhood, is sought to be controlled by the enforcement of the provisions of the Pest Act, which aims at the observance of a ' no cotton ' period between two successive cotton crops. The existence of the perennial variety, however, in the Pest Act area defeats the objects. The object of breeding is therefore the eventual elimination of perennial *nadam* cotton, which is inferior in quality, but resists stem-weevil, stands soil drought, and contains the least per cent of insect damaged kapas in the harvests. Earlier trials during the years 1933 to 1940 under the auspices of a scheme financed by the Indian Central Cotton Committee were aimed at its replacement by annuals. The trial of most of the annual types grown in Madras and other States showed them to be either too late in duration or too poor in productivity. All attempts to evolve annual types by hybridization did not yield useful biotypes. The response of *nadam* to pruning was not encouraging. The following conclusions were drawn from the experiments. All annual forms sown in September–October recorded poor yields due to erratic distribution of rainfall and peculiar soil conditions. The variability in *nadam* was not sufficient for the isolation of promising annual types. The progenies of crosses between *nadam* and *karunganni* which were hopeful in the early generations did not maintain the desirable characters in the later generations. It might therefore be concluded that in the *nadam* zone, hazards of weather and ravages of insects would be against the introduction of annuals. The future of *nadam* cotton improvement work requires a reorientation since the Lower Bhavani Project expected to be completed by 1952 will rope in most of the perennial area under irrigated Cambodia.

Karunganni unirrigated.—The cotton growers in ' *Tinnies* ' and ' *Salems* ' area usually raise a mixture of two distinct botanical types *karunganni* and *uppam*. It is commonly believed by them that in years of good rainfall, the *karunganni* component of the commercial mixture does well, while in years of scanty and ill-distributed rains *uppam* fares better. Such a practice brings down the intrinsic merits of *karunganni*, as wide variations exist in their fibre properties. It was not possible to discourage this practice in spite of propaganda and seed distribution done by the Agricultural Department. The evolution of an improved strain having a better adaptability and quality than the individual components of the mixture, was therefore considered as the only means of eliminating this variable mixture. The Madras Herbaceum Scheme financed by the Indian Central Cotton Committee, between the years 1923 and 1938, had for its objects the evolution of strains for the ' *Salems* ' area combining the hardiness of strains of local *uppam* with the productivity and quality of *karunganni*. The results of investigations revealed the following essential features. Variability in *uppam* was very low and as such it was not likely to respond to selection. Eleven strains

isolated from *uppam* by pure line selection were inferior to *karunganni* in all respects. The drought resistance claimed for *uppam* was not apparent in field studies. Its role was probably one of maintaining hybridity with *karunganni* at a fairly constant level in order that the advantage of such hybrid mixtures in bulk could be exploited. Extra-provincial *herbaceums* were misfits at Coimbatore. Hybridization within *arboreums* yielded seven strains excelling the standard *karunganni* in yield during good as well as scanty rainfall years. Out of these *K* 5 recorded a very consistent and uniformly good record of yield in all zones and centres in the *desi* cotton belt of the Cambodia tract. Its remarkable features are medium long staple of 7/8 inch, and capacity to yield on the high side under wet conditions in seedling stage and drought in growth period and to respond readily to the restricted irrigation practised in black soils of Palani and Udumalpet taluks. The unification of *desi* cotton area north of river Vaigai under one cosmopolitan strain is therefore an accomplished fact with the release of strain *K* 5. The seed distribution scheme working now at Palladam under the auspices of the Madras *Cambodia* 2 and *Karunganni* 5 combined seed multiplication and distribution scheme will eventually help in the conversion of the whole area into one of 30's warp cotton.

The new hybrids isolated from the Madras Herbaceum Scheme were further subjected to rigorous reselection and crossing to improve adaptability. Transgressive variations exceeding the parental values in staple length were obtained. *Desi* cottons were not so far noted to exceed 15/16 inch staple limit. Record lengths ranging from 1·5 inch to 1·09 inch by Balls' sorter which would be equivalent to 1-1/16 inch in trade were achieved. The yield increase was not as spectacular as either staple or ginning outturn. Selection was therefore confined to cultures possessing the agricultural adaptability of *K* 5 combined with other improvements. The selections under test are eventually expected to raise the normal yield of *karunganni* in Coimbatore and Tiruchirappalli districts to 100 pounds lint per acre and change the quality from 7/8 inch staple to full one inch. The spinning capacity will not however exceed 40's warp since there is very little change in the fibre weight.

Improvement work on 'Tinnies cotton' was started at the Agricultural Research Station, Koilpatti, in the first decade of this century. Since acclimatization of outside cottons did not yield a suitable type for the area, mass selection was practised in the local *karunganni* and two types *Company* 2 and *Company* 3 were released in 1914–15. They fetched a premium of Rs. 16 per 500 pounds lint over '*Tinnies*' local. The improvement was not lasting and due to gradual deterioration, the types fell out of the market. The next attempt at improvement was made through single plant selections and two strains *A* 10 and *C* 7 were isolated in 1920–21. Each had a preference for a particular

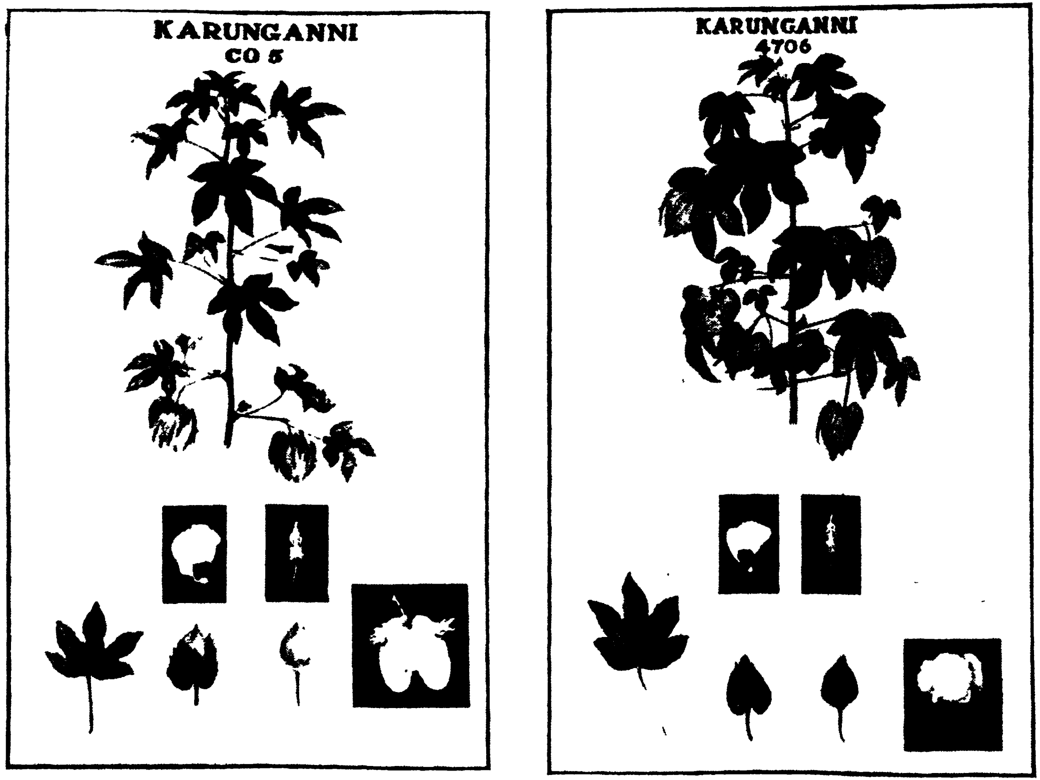


Plate 81 (*a*).—*Karunganni Strains*

tract and the maintenance of purity of both the strains was handicapped by this defect. Hence the need for a more cosmopolitan strain suited to a wider range of environmental diversity arose. Strain *K* 1 was isolated by further reselection in *C* 7 and was distributed on a wide scale from 1934–35. It is an early, drought resistant strain with a mean staple of 13/16 to 7/8 inch and ginning outturn of 31 per cent. The yield levels of 100 to 125 pounds lint was a definite improvement over *C* 7. It was susceptible to wilt and shedding of buds and bolls during untimely rains in January–February and was unsuited for areas where *uppam* was grown. This strain spread to over three lakhs acres by 1946–47, out of a total area of about 6·25 lakhs acres, partly aided by the seed multiplication scheme run at Koilpatti. The attempts made to evolve a biotype free from the defects of bud and boll shedding did not yield useful results. Work on this fundamental aspect was carried out for three seasons from 1936 under the auspices of a scheme financed by the Indian Central Cotton Committee. Gradually, however, the quality of *K* 1 deteriorated in spinning performance. Reselection from the existing *K* 1 did not yield fruitful results. Further work was directed towards the evolution of a cosmopolitan strain suited to both pure *karunganni* and mixed zones. As pure line work did not meet the needs of the tract, the hybrid derivatives obtained from the Madras Herbaceum Scheme at Coimbatore were subjected to rigorous reselection at Koilpatti. Strain *K* 2 isolated in 1939–40 was distributed to the cultivators in 1947–48 after extensive trials. It is a cosmopolitan strain with a wider range of adaptability and is not subject to bud and boll shedding, a defect noticed in *K* 1. It has a staple of 7/8 to 15/16 inch and a ginning outturn of 32 per cent with a spinning capacity of 30's warp. A scheme for the multiplication and distribution of *K* 2 seeds has commenced working in 1949 and the prospects of converting the entire 'Tinnies' area into one variety of 7/8 inch staple are bright. Further work on the improvement of staple length and ginning outturn by *karunganni* cotton is under way as part of the scheme financed by the Indian Central Cotton Committee from 1949.

The area under improved strains for the entire *karunganni* area in 1948–49 was 2·36 lakhs acres covering 48 per cent of the total area. The chief distinguishing features of improved *desi* varieties of the South are furnished in Statement 4 (A) appended.

Cocanadas unirrigated.—*Cocanadas* is the trade name of the variety of cotton grown in the districts of Visakhapatnam, Godavari, Krishna, Guntur, Nellore and a part of the Kurnool district in the State. It is a coloured cotton which has a mean staple length of 5/8 to 6/8 inch and a ginning percentage of 25. The natural tint of the cotton varies from drab to reddish brown and it is considered to be an asset in the manufacture of coloured textiles. It is preferred to other white cottons on account of its capacity for dye absorption and good fibre strength. The main drawbacks

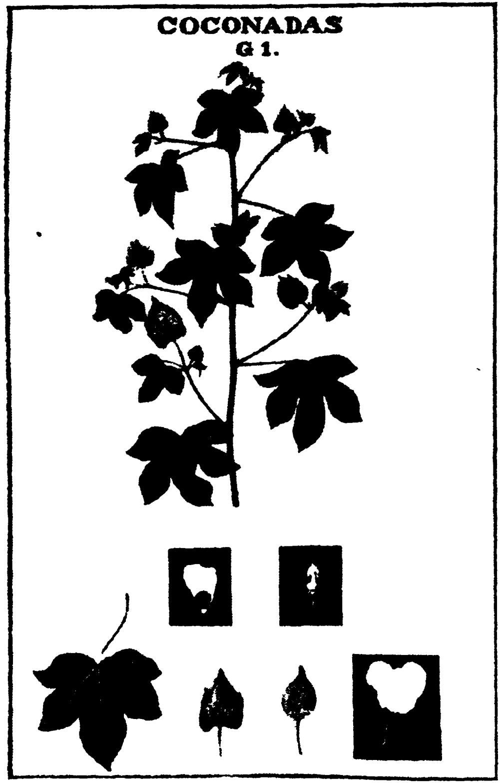
of this variety are the variable colour, short staple, low ginning and low yield. These defects are sought to be remedied through evolution of a better quality cotton.

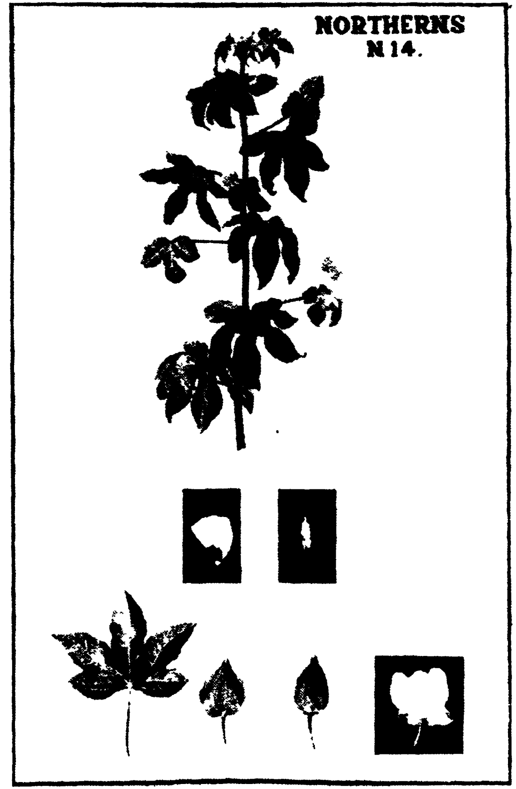
Earlier work at the Agricultural Research Station, Guntur, resulted in the evolution of G 1 (Cocanadas 1) a derivative of inter-strain hybridization within *arboreum*. It possessed medium staple of 7/8 inch and ginning capacity of 28 per cent, with a spinning value of 30's warp. Its lint colour was however lighter than the average local bulk. The consuming mills were in favour of this type in all respects except colour. It was however unsuited to the *Chinnapathi* area where short staple white cotton was grown.

The work of the red cotton improvement was taken up under the Madras Cocanada Scheme, financed by the Indian Central Cotton Committee from February 1940 at Narasaraopet in Guntur district served by another satellite station for deep black soil at Gurzala in the same district. A survey of the tract disclosed that this cotton was raised largely as a mixed crop on a variety of soils and seasons and that the major area comprised of the shallow type of loamy and gravelly soils. Patches of inferior white cotton existed in this essentially coloured zone in the districts of Guntur, Nellore and Visakhapatnam. The white cotton of the last named district known as *Chinnapathi* was entirely different from those of the other two districts in form as well as habit.

Breeding experiments were conducted in the three major seasons of planting, viz., July, August and September prevalent in the red cotton area both as a pure crop and as a mixture with *bajra*. Studies on the variability of economic characters in bulks and progeny rows revealed that the habit characters were effected by changes in environment and lint colour was modified by a change in locality of growth. Conjoint variability for all characters was absent in bulk collections. There was a wide scope for selection of plants with single attributes like staple, ginning or colour while the plants with deeper coloured lint always had shorter lint length and coarse fibre. Heritable variability for colour was abundant in Godavari district, but from the point of other attributes Guntur district possessed the largest useful variation.

The first batch of pure lines showed improvements in colour, ginning and yield but not in staple. The best of them was 129 which did not find favour with the consuming mills in India on account of its coarseness and short staple. In the new batch of pure lines, there was a slight improvement of mean lengths of the coloured selections, but there was no corresponding shift in coarseness as judged by the fibre weight. Selection 599 *A* 4-1 was the best biotype in this batch. The light brown gene was found to be subject to profound fading action possibly due to low dominance of the Peninsular *arboreums*. Since the task of effecting conjoint improvement in colour and staple





Coconadas Strain *Plate* 81 (*b*). *Northerns Strain.* P. 511

was felt to be difficult of achievement by pure line selection, work on hybridization was also taken up. Interstrain crosses between Cocanada pure lines involving strain *Cocanada* 1 did not yield biotypes exceeding the best of the parental pure line in staple. They, however, contributed to the advancement of productivity and ginning. Inter-racial hybridization was therefore taken up as the next promising line of attack. Crosses between *indicum* strains possessing staple, fineness and adaptability on the one side and *burmanicum* varieties having stable colour genes on the other were made and studied. Selections from these derivatives are in progress.

Among the earlier selections, two pure lines 336 *B* and 336 *D* combined to a very large measure the colour and quality standards. The existing strain *Cocanadas* 1 was superior to the local type in all respects except colour. It acquitted itself well in field trials, in valuations by trade and consuming mills and also in technological tests. A seed multiplication scheme for this variety was started in 1948 in Palnad taluk of the Guntur district to meet the needs of the light coloured zones of Nellore, Guntur and part of Kurnool district so that the general quality of the produce marketed from this area might be toned up.

Selection work for the *Chinnapatti* area is also carried out under the auspices of the Cocanada Scheme. This short stapled white variety is grown by the farmers in Visakhapatnam as *thola-kari* or *buradapathi* cotton mainly to meet their own clothing requirements. It has no export market and the whole of the produce is consumed for hand spinning in the production centres. Since this happens to be a patch of inferior white cotton in the red tract, the area was surveyed in order to select early types with fair staple. But there was no variability and a suitable type would have to be evolved only through proper synthesis. Conversion into a medium staple white cotton area or replacement by a coloured variety were the two alternative possibilities. *Cocanadas* 1 was unsuitable on account of its late habit. Hybridization with early types was taken up to evolve a biotype. They are in early stages of breeding but nevertheless show great potentialities in ginning and quality. Nineteen early improved *arboreum* white strains evolved in the Punjab, Bombay, Uttar Pradesh, Madhya Pradesh and Madras were compared as a pure crop with *Anakapalli* white to study their adaptability, earliness and quality. It was seen that the majority of the cultures were as early as the control and the choice had to be on the staple, ginning and fineness. 881-*F* and 197-3 proved their adaptability and combined many good qualities. It would be desirable to recommend 881-*F* in order to ensure unification of *Mungari* and *Chinnapatti* zones which are in most respects identical. In a separate trial containing Upland American types, *Pharbani American*, *L. II*-40-594, *L. II*-43-8380, *M.A.* 2, 6752-*B*, and 7795 equalled the *desi* local in seed cotton yields but were definitely superior in staple length and ginning per cent. Further work is in progress.

Northerns unirrigated.—The existing '*Northerns*' area is confined to Kurnool district and comprises of three indigenous varieties, viz., white Northerns (*arboreum* and *herbaceum*) including gadag and red Northerns (*arboreum*). The district is divisible into three broad zones of Western, Central and Eastern Kurnool differing in soils and climate. The western zone, comprising mainly of the Pathikonda taluk very much akin to the Bellary district which it abuts, grows Westerns (*herbaceum*) cotton. The Eastern area is closely allied to the red Coconada zone and is contiguous with it in the matter of variety grown and seasons of cropping. It is only the central zone, which grows a multiplicity of varieties, viz., white *Northerns* (*arboreum*) *gadag* (*herbaceum*) and *mungari* (*arboreum*), and which is served by the Agricultural Research Station, Nandyal, that requires improvement. The commercial crop marketed under the name of *White Northerns* consists of a mixture of these non-descript varieties. The staple length and quality of these varieties are variable, the yield is low at about 50 pounds lint per acre, and the ginning outturn is about 26 per cent.

Pure line selection on *Yerrapatti* (red Northerns) commenced in the year 1908–09, at the Agricultural Research Station, Nandyal, resulted in the isolation of the white strain *Northerns* 14 possessing a staple length of 24 m.m., a ginning outturn of 24 per cent, and a spinning capacity of 40's warp. Its general distribution began in the year 1918 with the aid of seed farms run by the Agricultural Department. On account of its limited adaptability and low ginning outturn, its cultivation was always confined to certain favoured localities in the area. A second wave of pure lines evolved during the period 1920 to 1940, could not excel the high standards of quality built up in *Northerns* 14, though small improvements in yield or ginning were obtained. Inter-racial hybridization within *arboreums* using *bengalense* and *cernuum* as parents since 1925 did not yield fruitful results. The work was intensified in 1938 employing many extra-provincial *arboreum* varieties and the technique of back-crossing. Interstrain crosses between local strains evolved at Nandyal were also studied. All of them proved to be either shy bearers or lacked the requisite variability to respond to selection. Fresh crosses using foreign long staple *arboreum* varieties evolved in the Madras Herbaceum Scheme were made and studied since 1943. It was found that *Million Dollar* from China and two other types, namely, 1523 and *L.* 3–4–4 produced high variability in crosses with *Northerns* 14. Among them, 1523 gave rise to a group of progenies having mean staple lengths ranging from 25 m.m. to 27 m.m. and mean ginning from 28 per cent to 34 per cent at the adaptability level of *Northerns* 14. Later crosses advanced these standards further to 1·02 inch staple by Balls' sorter and 34 per cent ginning. Some of them are in bulk stages of testing for yields and trial in cultivator's holdings. In order to intensify the programme of selection through hybridization, a new breeding scheme financed by the Indian Central

Cotton Committee was initiated in 1949. It has for its objects the evolution of a cosmopolitan variety possessing adaptability over a wide range of soils, and capacity for increased yield per acre and ginning per cent over *Northerns* 14, without affecting the present qualities of staple length and fineness of *N* 14.

Mungari unirrigated.—A low grade, short-staple and coarse-quality cotton akin to '*bengals*' is being grown on the red and mixed soils of Ceded districts during the *kharif* season. Its presence in an area of medium-stapled cottons like *Westerns* and *Northerns* leads to undesirable mixing and hampers the spread of *Westerns* 1 and *Northerns* 14 varieties in a pure form. These evils were sought to be checked by breeding for a medium-staple variety suitable for cultivation in the *kharif* season, and work towards this end was started in the year 1937 as part of a scheme financed by the Indian Central Cotton Committee.

The first part of the work consisted in the trial of improved strains obtained from stations in and outside the State. These were tested for yield in breeding plots at Adoni and in representative villages in the districts of Bellary, Anantapur and Kurnool in replicated bulk trials. During this stage of the work *stenosis*, a disease later proved to be of virus origin, was noticed to be fairly common and was estimated to reduce considerably the crop yields on account of the attacked plants turning either partially or fully sterile. Collections of improved American varieties were also included in the later years. These were found to be immune to the virus but were affected by *thrips* and drought. Of the 38 Asiatic and American strains tested for over three seasons, the most promising varieties failed to satisfy one or more of the standards set forth for yield, earliness or quality. *Cambodia* 4 did well only in light-black soils and though free from *stenosis*, suffered from *thrips*. *Strain V* 434 was highly susceptible to *stenosis* and possessed low ginning. *Westerns* 1 and *Northerns* 14 were failures during the *mungari* season as they could not finish their yields early along with the *mungari* bulk. The breeding aspects consisted of the study of variability of *mungari* bulks and reselection in improved varieties and crosses that were available or made with extra-State types. Two other new varieties, viz., *umri Bani* and *jarilla* satisfied the standards of earliness but lacked ginning or yield. Improved strain 881-*F*, a reselection from *C* 6-3, was very promising when tested in bulk plots on cultivators' holding since 1944. It recorded yields ranging from 100 to 115 pounds lint per acre and fetched a value equal to Farm *Westerns* in the market. Its staple could be classed equal to 7/8th inch with a spinning capacity of 30's warp as compared to the 10's of local *mungari*. Its two drawbacks, however, are late habit and low ginning outturn compared to the *mungari* bulk. Nevertheless, work on the rapid multiplication and distribution of strain 881-*F* is under way in addition to breeding for the evolution of biotypes which would prove as improvements over 881-*F*. Further trials with early maturing *arboreum*

types disclosed that Koilpatti selections *K*-19, *K*-21, *K*-28 and *K*-32 were as good as 881-*F* in staple and yield, superior in ginning by 4 per cent, and equal to local in earliness. Hybridization to combine high ginning and earliness with the yield and lint qualities of 881-*F*, was programmed and partly executed. The variability created is expected to yield a biotype satisfying in all respects the needs of the *mungari* tract in respect of yield, earliness and high ginning. Further selection work with these objectives in view is under way. Small-scale trials of 881-*F* and Koilpatti types *K*-19, *K*-21, *K*-28 and *K*-32 in the *hingari* season at the Agricultural Research Station, Hagari, proved that these were as good as *hingari herbaceum* strain in yield, but decidedly superior in staple and ginning. There is thus great scope for unifying the whole area with one type in both *mungari* and *hingari* cropping. The trial of American varieties on both the soils supported the findings at the Agricultural Research Station, Siruguppa, that suitable biotypes could be evolved for August sowing from *MA* 2, *Gadag* and *Hyderabad races*. The yield tests proved that the productivity of *munagari* could be realised in *hirsutum* but this performance remained to be corroborated in extensive trials over the whole *mungari* tract.

Westerns unirrigated.—The rain-grown *desi* cotton on the black soils of Bellary, Anantapur and Cuddapah districts and Pattikonda taluk of Kurnool district is a medium staple—warp quality cotton belonging to *herbaceum*. Low and fluctuating yields and quality together with wastiness of the cotton were common defects noticed in the crop marketed under *Westerns*. Pure-line selection carried on at the Agricultural Research Station, Hagari, from the year 1908 resulted in the isolation of strain *Westerns* 1, which was released for general cultivation in the year 1930. It marked a substantial improvement over both the *jowari* cotton (unselected *Westerns*) and earlier selection *H* 25 in the matter of staple and ginning. It had 13/16 to 7/8-inch staple, and 28 per cent ginning with a spinning capacity of 26 warp. Further improvements were sought in ginning outturn, fibre weight and capacity for drought evasion through breeding. Since the tract is subject to low and variable rainfall, big improvements in seed cotton yield or staple lengths are more difficult to achieve than advances in ginning or fineness. Similarly drought evasion rather than drought resistance will be a feasible proposition.

A wide collection of *herbaceum* varieties from Bombay and Iran was made and studied before using them as parents in hybridization with local races. The Bombay types were found to be late maturing and unsuitable for the arid black soils of Ceded districts. Some of them, however, were desirable from other aspects. They possessed resistance to *fusarium* wilt bordering on immunity, staple length, low fibre weight and high ginning outturn. They were therefore employed in crossing with *Westerns* 1 for imparting the above characters. The hybrid derivatives are in different stages of

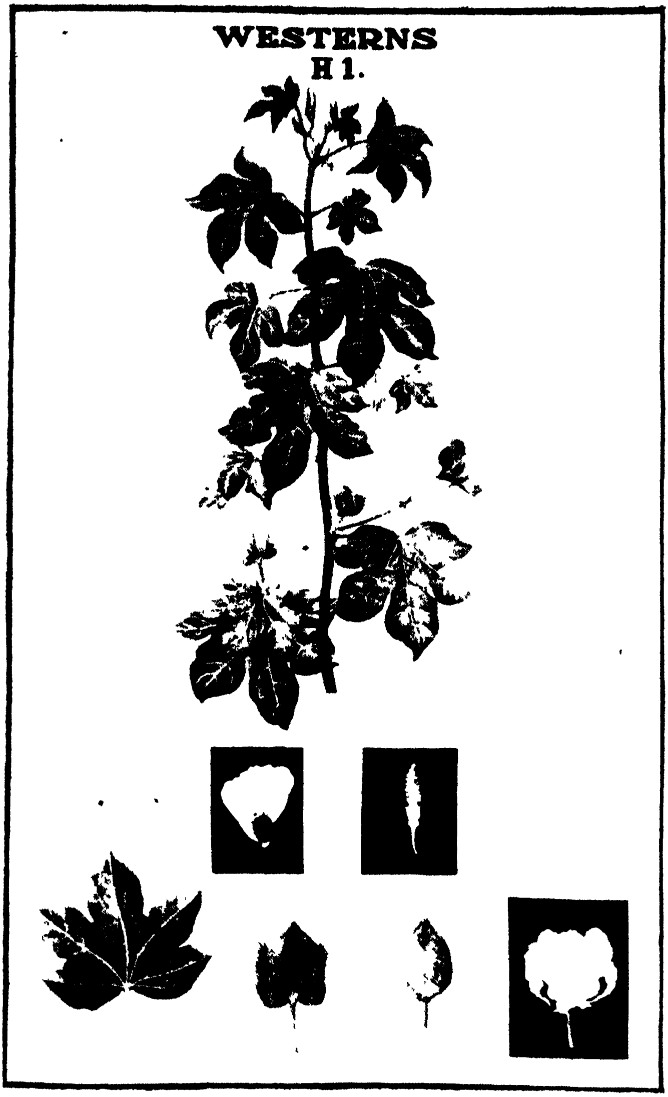


Plate 81 (c).

test and purification. It is found that *Iran* brings in earliness and fineness while Bombay types contribute to staple fineness and ginning. A few of them satisfied the standards of staple, ginning and fibre weight set as the original objective.

Among fresh extra-State collections, the Dharwar and Surat types responded to re-selections for early habit and productivity. Type 2–3–69 from Dharwar yielded as much as the biotype 2800 evolved through hybridization while retaining the better staple and ginning per cent. In addition to these, trial of early *arboreum* varieties was continued for finding whether the whole of the *Westerns* area including mungari could not be unified under one common *arboreum* strain. Types which compared well with 881-F at Adoni in *mungari* season were tested against *Westerns* 1 at Hagari. 881-*F*, *K*-19, *K*-21 and *K*-22 yielded as much as local but possessed advantages in staple, ginning and fibre strength.

With a view to intensify the programme of hybridization among *herbaceum* varieties and a scheme financed by the Indian Central Cotton Committee was sanctioned in 1949. The scheme at its termination is expected to yield one lakh bales of quality *Westerns* capable of spinning 30's warp with a basic staple length of over 13/16 inch. A seed multiplication and distribution scheme has been working at Guntakal since 1942 for spread of strain *Westerns* 1 which covered 59 per cent of the total area under *Westerns* cotton in the year 1948–49.

The chief distinguishing features of *desi* cotton strains are furnished in Statement 4 (A) and (B) appended. The breeding work on rainfed *desi* in the State has been directed towards the conversion of the entire area into one of medium-quality cottons of 7/8-inch staple capable of spinning up to 40's eliminating inferior short-staple styles. To this end remarkable achievement has been recorded. through planned hybridization and selection for quality.

In addition to pure-line selection and hybridization *inter se* practised for improvement work on Cambodia cotton, polyploidy and distant hybridization involving wild cottons are the special methods adopted. *G. hirsutum* hybrids with fertile wild cottons, viz., *G. taitense* and *G. darwinii* taken to fourth generation combined to a satisfactory degree fertility, staple length and adaptability. Latest knowledge about wild cottons indicated that *G. darwinii* is allied to *G. barbadense* than *G. hirsutum*. Similarly *G. taitense* is closely related to *G. hirsutum* but not to *G. barbadense*. This possibly explains the transgressive variation noticed in the cross (*G. darwinii* × *G taitense*) × *G. hirsutum* 4463. Large-scale employment of *G. darwinii* in crossing as one way of bridging up the species gap between Sea Island and Upland varieties has been in progress at Coimbatore. Staple lengths of 1·13 inches, fibre weights of $1{\cdot}14 \times 10^{6}$ grammes per centimetre and maturity of 81 per cent in winter Cambodia are new records worth the time

and labour spent on the synthesis. Most of the selections made in this group are under progeny row tests in both irrigated and unirrigated trials.

The sterility of hybrids with *G. raimondii* was got over through doubling with colchicine and the resulting fertile hexaploid (4463 × *G. raimondii*) was stepped down to tetraploids through crossing with both *hirsutum* and *barbadense* varieties. Fertility judged from the bolling capacity in the field was a reliable and safe index for selection. This material in the fourth generation contains new polyploids possessing good vigour, high drought resistance and fine quality and will be useful in developing unirrigated American areas or replacing *desi* cottons in black-soil region.

Among the several techniques adopted for the improvement of rainfed *desi*, hybridization involving *G. anomalum* for transferring genes for boll-worm resistance and low fibre weight was employed. Crosses and back-crosses of anomalum effected with long-stapled varieties in cultivated South Indian *arboreums* inclusive of Cocanadas cotton are in the second back-cross stage.

AGRONOMIC TRIALS AND EXPERIMENTS.

Agronomic enquiries on cotton have been initiated from time to time in the different Agricultural Research Stations of the State or as part of the several schemes financed by the Indian Central Cotton Committee, which invariably took into consideration the earlier experience gained at the stations. Specific experiments were undertaken to evolve efficient systems of agricultural practice aiming at maximum production, utilizing the available resources with due regard to the need of the tracts and solving difficulties encountered in executing breeding programmes. The "time of planting" trials conducted at the Agricultural Research Station, Palur, is a good example. A shift in planting date from March to December trebled the yields of irrigated Cambodia, an experience unparallelled in any other crop for a single agronomic practice. The following in brief are the different problems tackled so far.

*Planting date-*cum*-spacing trials.*—With a view to assess the relative effects of early and late sowing on the yield of irrigated Cambodia, replicated trials were conducted at the Cotton Breeding Station, Coimbatore, during the years 1927–30. The mean yields obtained were 1,080 pounds seed cotton per acre for the crops sown on 1st September while those planted on 1st October and 21st October recorded 611 pounds and 152 pounds respectively proving thereby the definite advantage of early sowing. It was also seen that the early sowings had a slight adverse effect on the succeeding sorghum crop possibly due to longer stand of cotton in the field depleting soil fertility. The ryots in the major part of Coimbatore district have readily taken to the earlier planting of cotton after sorghum, but where ragi is grown in rotation, the sowings are

unavoidably delayed due to the late harvest of ragi crop. The belief current among such growers that the loss in yield, by late planting, can be compensated by an increase in the seed rate adopted for cotton, is being tested in the experiments with different spacings and dates of planting conducted at Coimbatore since 1947. The trend of the results indicates that a close spacing of three inches between plants restores fully any loss resulting from delayed sowings up to 20th September but not later. Close observations on the field behaviour of plants disclosed the pre-disposition of late sown crop to severe attack of the insect pest *jassid* (*Empoasca Spp.*). Further enquiry is being made to find out whether insecticidal measures of controlling *jassids* will help to solve the problem of low yield of late sown crops.

Flower shedding, motes (unfertilized seeds) misshapen boll development, imperfect boll opening and poor yields in an apparently good crop were some of the serious defects noticed in the summer cotton raised at the Agricultural Research Station, Palur. A subsequent survey of the cotton growing areas of the South Arcot district and personal enquiries made of the observant farmers revealed that flower shedding in May-June followed by a period of recovery from July onwards was a common feature of the tract. Among the various correctives and ameliorative measures tried after a due recognition of the basic causative factor, viz., contabescence of anthers resulting in flower shedding, a shift to earlier planting dates was one. The variants tested were different planting dates at fortnightly intervals from December to March with different varieties and spacings. The results disclosed that the December sown crop dodged the ill-effects of high temperature during flowering phase and recorded yields nearly three times the March sown crop in all treatments. The increase in yield was traceable to both increase in flower production and decrease in flower shedding arising out of contabescence of anthers. The mean yields of seed cotton for the December sown crop was 1,012 pounds while the March planted crop recorded 659 pounds per acre.

Planting date and spacing trials were conducted at the Agricultural Research Station, Siruguppa, during the years 1938–1948 with the object of finding out the optimum period for *rabi* planting of cotton in the Tungabhadra Project area. The investigations disclosed the following essential features. The optimum planting period for irrigated American cotton was about the second week of August. Types like *M.A.* 2 showed the greatest adaptability for all planting dates. The crop sown after 15th September suffered from severe *jassid* attack and showed poorer productivity and lint qualities. Closer spacing and earlier planting dodged the attack of *jassids* more effectively.

With a view to determine the optimum spacing for irrigated cotton, eleven graded spacings varying from 24 inches to 4 inches along ridges formed uniformly 3 feet apart were tested at the Cotton Breeding Station, Coimbatore, for six seasons from 1929,

The results were found to vary from year to year as seasonal factors influenced a great deal. In years of good rainfall, wider spacing was beneficial while in seasons of poor precipitation the effect of spacing was not felt. Spacing experiments in rainfed black soil during 1929 to 1933 indicated similar modifying influence of both amount and distribution of rainfall.

Spacing.—At the Agricultural Research Station, Koilpatti, experiments on the effect of spacing on cotton indicated that the optimum spacings between rows and between plants were 18 inches and 8 inches, respectively. The yield of a late sown crop could not be increased by closer spacing in the rows. A popular misconception among the ryots of the 'Tinnies' tract was that drill sowing would not permit the sowing of subsidiary crops along with cotton. This was dispelled by suitable experiments. Coriander with a low seed rate of three pounds per acre and blackgram proved good mixtures while horsegram was found to depress the yields of cotton.

The results of spacing experiments conducted at the Agricultural Research Station, Hagari, between 1924 and 1926 and 1931 and 1935 indicated that a spacing of 36 inches between rows was as good as 27 inches. An adoption of this wider spacing will result in a saving of seed for sowing.

Seed rate.—Between the years 1928 and 1934, experiments were conducted at the Cotton Breeding Station, Coimbatore, to find out whether it would be possible to enhance the acre yields of cotton by allowing two plants per hole instead of one. The results indicated that the efficacy of the device depended upon several factors like system of cropping, variety, spacing, fertility status of the soil and rotations practised. In soils which had been rendered fertile by either manuring or judicious rotation, double plants were of decided advantage over single plants. In poorer soils single planted crop scored over the double planted one.

Thinning.—Experiments to find out the effect of thinning on yield of cotton conducted between 1907 and 1910 at the Agricultural Research Station, Hagari, disclosed that on the black soils of Ceded districts thinning of cotton was not found profitable.

Place effect.—A belief is current among the ryots that *karunganni* seeds raised in Tirunelveli district produce a better crop when planted at Coimbatore and that seeds produced in Palni taluk prove superior to local seed for raising in Tirumangalam area. The validity of this conception was not proved in experiments during 1938 to 1941 with seeds of Karunganni 1 obtained from the different centres.

Electro-culture.—Experiments were conducted for two seasons (1938–40) wherein Cambodia cotton seeds were sparked dry or soaked in sparked water for varying periods before sowing and were further

irrigated with sparked water. It was found that none of the treatments could induce any differential response either in germination, subsequent growth or in final yields.

Irrigation.—Irrigation experiments on Cambodia cotton were conducted at the Cotton Breeding Station, Coimbatore, during 1929 to 1936 with the object of finding out the optimum interval between two successive irrigations, the minimum number of irrigations that would be necessary after the cessation of the north-east monsoon and the best time for giving these irrigations. The results indicated that irrigating once a week was wasteful and least economical while there was hardly any difference in yields between plots irrigated once a week and once in three weeks. It was also seen that a good crop of Cambodia could be taken with only two irrigations after the cessation of the north-east monsoon. They were best given by about the second week of December and January. Besides the above conclusions, the following useful information was also gathered from the experiments. More water per irrigation was absorbed when the interval between two successive irrigations became longer, but the relation was not directly proportional. Plots irrigated once in twenty days absorbed only a little more water than those irrigated once in ten days. The manured plots consumed a little more water per irrigation than the unmanured plots. Spacing between the plants in the row did not interfere with the water requirements. Waterings given at the flowering phase were more important than those given at regular intervals. The humidity of the plots could on no account be controlled by manipulating the frequency of irrigation, as the diurnal variations in humidity was so much as to mask completely any fluctuations which might arise out of differential irrigation.

Rainfall and cotton yields—An examination of the relation between rainfall received and yield of Karunganni cotton at the Agricultural Research Station, Koilpatti, during the years 1910–1930 revealed that for obtaining maximum yields of cotton, the following distribution of rainfall would appear to be most beneficial :—

(1) A heavy rainfall in the two fortnights preceding sowing, followed by a light precipitation of one to two inches in the first fortnight after sowing.

(2) A dry spell during the second and third fortnights after sowing followed by good showers in the fourth fortnight.

(3) Another dry spell in the fifth, sixth and seventh fortnights, especially the last mentioned period.

(4) Fairly good showers in the eighth to tenth fortnights.

A statistical study of the effect of each inch of rainfall on the yield showed that extra rain had a negative influence on the yield, almost throughout the year.

Experiments conducted during the years 1932 to 1935 on the two different methods of irrigation, viz., furrow or flat-bed revealed that slightly less water per irrigation was consumed in furrow irrigation while the yields were not affected. However, planting the seed on ridges or beds did not affect the water requirements provided the level of the field was uniform in both.

Two series of irrigation experiments are in progress at the Central Farm, Coimbatore, since 1938. The normal water requirements of Cambodia Cotton from sowing to harvest as determined in one of the series of experiments ranged from 22·48 to 36·20 acres inches of water. Seed cotton yields ranging over 1,000 pounds per acre were recorded for the above water consumption. In the other series, the object is to determine the optimum interval between two successive irrigations and the optimum depth of water per irrigation. Reliable results were obtained only in three seasons. Three acre inches of water applied at intervals of two or three weeks appeared to be the most economical.

At the Agricultural Research Station, Siruguppa, irrigation experiments on cotton were conducted. In the physico-chemical studies conducted on the *hingari* block the frequency and depth of irrigations were included as additional items (1939–43). But the treatment effects were not significant as they recorded poor yields. In *mungari* cotton, a comparison was made between irrigated and dry crops (1940–43). The irrigated series gave significantly better yields with mean of 364 pounds seed cotton per acre while the dry crop recorded 263· pounds. The *hingari* cotton responded better to irrigation given every fortnight and recorded higher yields than the plots irrigated once every month. In 1943–44, the total water consumed was 26·01 inches and 21·96 inches for corresponding yield levels of 993 pounds and 840 pounds of seed cotton per acre for the two treatments. Another experiment conducted in 1945–46 for comparing flat bed *versus* ridge irrigation did not show significant difference in yield response.

Soil culture.—Experiments on pre-cultivation were started at the Cotton Breeding Station, Coimbatore, in 1940–41 under a scheme which was originally programmed to continue for ten seasons. The object was to determine the minimum preparatory cultivation for rainfed cotton and sorghum under red and black soil conditions.

The following ten cultural treatments were tested :—

1 No ploughing	These plots were not worked with any implements, but if the fields were weedy during off season, they were removed with the least disturbance to the soil.
2 Ploughing with country plough ..	Two times.
3 Do. ..	Four times.
4 Do. ..	Six times.
5 Do. ..	Eight times.

Plate 82.—Inter-cultivation in Cotton.

6	Ploughing with Cooper No. 26 ..	Once.
7	Do. ..	Twice.
8	*Guntaka*	Once.
9	*Do.*	Twice.
10	Standard	After working a Victory plough once country plough was worked next. *Guntaka* and junior hoe were worked later, if any necessity arose for the removal of weeds or crushing clods.

All the ten treatments were applied to red soil but in the black soil group, item 8 was omitted and replaced by a standard treatment.

Pre-cultivation.—There were no consistent results for seven seasons possibly due to the differential effects of erratic monsoons experienced during this period. The cereal in red soil failed to register any increase over control treatment in normal years, while greater frequency of cultivation in seasons of deficit south-west monsoon rains, tended to deplete soil moisture rapidly. Under conditions of heavy precipitation, intensive pre-cultivation with country plough created a very fine and loose tilth which was found to be very disadvantageous at the time of sowing as it generally gave poor germination. Uncultivated plots were continuously weedy in spite of frequent hand-weedings and the weeds were more at the end of the six-year period than at the beginning of the experiments. The trend of cotton yields followed that of the cereal. Cotton and sorghum were equally affected in seasons of heavy rainfall by poor germination and retarded growth in excessively-cultivated soils. Control treatment and the Cooper plough were the best. At the Agricultural Research Station, Koilpatti, experiments to test the effects of different methods of preparatory cultivation on the yield of cotton, showed that all the three treatments, viz., ploughing with monsoon plough, working *guntaka* and no ploughing, were alike in their effects on cotton yields.

Experiments on pre-cultivation at the Agricultural Research Station, Nandyal, during 1932–33 and 1940–46 disclosed that the deep black soils did not require so much of preparatory cultivation as would be beneficial to red and mixed soils.

Inter-cultivation.—With a view to determine the relative effects of inter-cultivating cotton by various methods, a series of experiments were conducted in the rainfed red and black soils of the Cotton Breeding Station, Coimbatore, during the years 1932 to 1936. Removing weeds with hand hoes only taking care not to disturb the soil and by disturbing the surface soil in addition to the removal of weeds either by hand hoe, country plough, *guntaka* or junior hoe were the different treatments tried. The inter-cultivation was done either once or repeated twice or thrice during crop growth. The operations were carried out when the soil was in a normal condition or just beginning to crack. The results showed conclusively that any inter-cultivation beyond keeping the land clean of weeds was quite unnecessary for cotton raised

in both red and black soils. At the Agricultural Research Station, Koilpatti, no difference was seen in the yield response of cotton grown on plots differently inter-cultivated.

Experiments conducted at the Agricultural Research Station, Nandyal, during 1937–40, with varying frequencies of working the blade-harrow indicated the need for clean cultivation and checking weed growth to obtain good yields of cotton.

Post-cultivation.—An experiment designed with the object of determining the least expensive method of post-cultivation to be adopted for a field of sorghum stubbles was conducted for two seasons during the years 1942–45 at the Cotton Breeding Station, Coimbatore. The following operations were done either immediately following the harvests of sorghum or after receipt of rains in April-May :—

(1) Working country plough as often as necessary to keep down weeds.

(2) Working *guntaka* periodically.

(3) Working country plough twice and then working *guntaka* when necessary.

(4) Ploughing with mould-board plough once and then working country plough.

The results indicated that both in gross yields of cotton following the sorghum crop and economics of early post-cultivation with *guntaka* following the harvest of sorghum was the best, the mean increase in cotton yields being eight pounds lint per acre.

Experiments were conducted at the Cotton Breeding Station, Coimbatore, during 1939–48 with the object of determining the relative effects of different preparatory cultivation for six crops sown and also to study their after-effects on cotton and sorghum. The plots were laid out in split plot technique with four main treatments and six sub-treatments.

Main treatments.	Sub-treatments.
Cultivation-cum-*Rotation*—	
A. Unploughed.	1 Sorghum (*periamanjal*).
B. Victory plough.	2 Bajra.
C. Country plough.	3 Sorghum (*Irungu*).
D. *Guntaka.*	4 *Tenai.*
	5 Cotton.
	6 Bengalgram.

The results disclosed that there was no differential effect due to cultivation in general except for odd disturbing results recorded for *sorghum* in 1943–44, cotton in 1944–45 and *bajra*, *tenai* and gram in 1945–46. In the rotations, cotton succeeding gram topped in yield while cotton following *sorghum*, *tenai*, *bajra* and cotton were in the descending order of superiority. The yields of *periamanjal* sorghum and other cereals were low on account of late sowings.

Manuring.—The manurial trials on cotton conducted in the Madras State during the earlier years of 1922–28 were simple and empirical with two sources of nitrogen, viz., ammonium sulphate and sodium nitrate not exceeding twenty pounds per acre. The next stage of trials conducted between 1929–35 included variations in kind and dosage of nitrogenous manures with and without phosphoric acid on basal applications of bulky organic manures.

Fertilizer experiments on irrigated cotton with chemical manures like ammonium sulphate, super-phosphate and potassium sulphate, were conducted at the Cotton Breeding Station for three seasons during 1928-31 and a review of the results brought out the interesting fact that the garden lands rendered rich by frequent application of fairly heavy doses of farmyard manure, were not benefited by the applications of ammonium sulphate. But for poor lands which had been brought under irrigated condition recently, the application of ammonium sulphate was beneficial. In either case, the addition of super-phosphate or potassium sulphate or both along with ammonium sulphate did not result in any additional benefit. Another interesting finding was that *kapas* produced from regularly manured lands contained a lower percentage of immature fibres.

No favourable response for top dressing of ammonium sulphate up to one and a half cwt., at the time of bud production was seen in experiments during 1930–32 although the practice was claimed to have increased production and enhanced the retention of buds, elsewhere. In order to assess the residual effect of manures, if any, under Coimbatore conditions experiments were conducted in both irrigated red soil and rainfed black soil during 1929–33. Two cwt. of ammonium sulphate and one cwt. of super-phosphate were applied to lands which had already been given a basal dressing of nine cart-loads of farmyard manure per acre. The results obtained for three years showed that the response in all the three years in irrigated red soil and in two years in the rainfed red soil was absent.

A treatment identical with the one indicated above in connexion with direct manuring of cotton was given to sorghum crop immediately preceding cotton. The effect on cotton following sorghum was noted. The crop failed to show any favourable response to this indirect manuring in irrigated red soil in all the three years. In the rainfed black soil favourable response was noted only in one year and even here the value of the increased yield was not commensurate with the cost of manure applied.

During the years 1939–41 experiments aimed at finding out the effect of one to four cwts. of ammonium sulphate applied during the different stages of growth of rainfed *desi* cotton in black soil were conducted at the Cotton Breeding Station, Coimbatore. No conclusive and dependable results could be obtained from these experiments.

Experiments on Cambodia cotton at the Central Farm during 1944–47 at different doses of nitrogen with and without phosphoric acid failed to give significant results.

In the trials conducted at the Agricultural Research Station, Palur, on irrigated cotton, no definite indications were obtained possibly due to flower shedding resulting from contabescent anthers.

At Siruguppa, 40 to 80 pounds of nitrogen in any form with or without bulky manures increased seed cotton yields by a substantial margin.

At the Agricultural Research Station, Nandyal, the experiments during 1930–34 revealed that it was more economical to apply cattle manure to sorghum crop than to cotton as the cereal responded to direct manuring and the residual effects were found to benefit cotton. The application of artificial manures like ammonium sulphate, super phosphate and oil cakes though found to give increased yields was not economical when the costs of manures was taken into consideration.

At the Agricultural Research Station, Koilpatti, manurial experiments definitely established that cotton responded to direct application of nitrogenous manure whether organic or inorganic. Cattle manure at ten cart-loads per acre increased cotton yields by 50 to 75 per cent when applied continuously for six seasons. Fifty pounds nitrogen per acre in the form of neem cake increased the yields by 50 per cent. Sheep penning at 1,000 sheep per acre was also found to increase the yield of cotton up to 60 per cent and the best time for sheep penning was a month prior to sowing. Twenty pounds nitrogen per acre as ammonium sulphate increased the yield by 13 per cent. Two cwts. of ammonium sulphate and one cwt. of super phosphate per acre gave an increase of 40 per cent. Forty pounds of nitrogen as groundnut cake and one cwt. of super phosphate increased the yield by 35 per cent. There was no difference between nitrogen in the form of groundnut cake or ammonium sulphate in their effect on cotton.

At the Agricultural Research Station, Hagari, an experiment started in 1948 with the object of studying the effect of 30 pounds of phosphoric acid in the form of super phosphate, disclosed that the application did not result in earliness either in flowering or maturity.

Co-ordinated manurial trials on rainfed cotton were conducted at Research Stations at Koilpatti, Guntur, Nandyal, Hagari and Coimbatore, as part of the All-India Scheme during the years 1943 to 1948. The object was to study the relative efficiency of nitrogen in the form of ammonium sulphate and groundnut cake and the comparison between the application of manure by broadcasting on the surface or drilling it into the soil. The doses of nitrogen ranged from 0 to 100 pounds per acre. There was no difference in response between ammonium sulphate and groundnut

cake, except under conditions of high fertility and presumably for large quantities of nitrogen, when ammonium sulphate was found to give a somewhat higher increase in yield. The method of application made no difference with ammonium sulphate which may be broadcast; but groundnut cake was better when drilled under conditions of high fertility and for large applications. The rate of increase in yield for unit quantity of nitrogen increased with increasing fertility. Manuring was not found profitable on land of low fertility except under extremely favourable price conditions. On land of medium and high fertility, manuring would be generally profitable.

The general principles of manuring as obtained from the results of experiments on cotton in Madras can be summarised as under. No benefit will be obtained by manuring rain-grown cotton in areas receiving less than thirty inches of rainfall. Hence, the production in "Westerns" area cannot be increased by manuring. In areas with rainfall over thirty inches, nitrogen at 40 pounds per acre can be recommended. The "Tinnies" area gave consistently high response. In the Siruguppa tract, representing the future Tungabadra area, there was favourable response to nitrogen even up to eighty pounds per acre in dry lands freshly brought under irrigation. In South Arcot district no definite conclusions could be drawn due to occurence of contabescent anthers and attendant ill- effects. The manuring in the Coimbatore area should be advocated to fields which are intensively cropped and which do not receive adequate quantities of cattle manure.

Trace elements.—Application of boron at ten pounds per acre was reported elsewhere to improve the growth of cotton plants, to reduce bud and boll shedding and to increase the yield phenomenally. Tests conducted at the Cotton Breeding Station during 1933–34 failed to support these findings.

In an experiment during 1929–30 application of slaked lime increased the yield of cotton by about 30 per cent. During 1928–29, cowpea ploughed into the field as whole plants stimulated higher yields in cotton than when the same was ploughed in as mere stubbles. Sunnhemp grown and ploughed *in situ* was found to improve the yield of cotton during 1929–30. In 1933–34 it was grown between rows of cotton seedlings with a view to use it as green manure to growing cotton plants as is done for sugarcane. The growth was poor and the green manure did not show any beneficial after-effect when it was ploughed in later on

Pre-treatment of seeds.—Experiments to study the effect of sowing cotton seeds coated with Ammonium Sulphate were conducted for two seasons (1942–44) with Cambodia cotton at the Cotton Breeding Station, Coimbatore. The results disclosed that the treatment did not lead to any increased yields claimed by other workers but on the other hand there were definite adverse effects on germination.

Rotation.—With a view to determine the relative yield response of cotton when raised after sorghum, *bajra*, *ragi* sunnhemp, groundnut and fallow, experiments were conducted at the Cotton Breeding Station, Coimbatore, during 1931–34. Sunnhemp, groundnut or fallow increased yield of succeeding cotton. Further experiments were started in 1940–41 to study the effect of six crop rotations on sorghum and cotton.

Treatments.

1 Cotton	Cotton	Cotton.
2 Bengalgram	Cotton	Sorghum.
3 Sorghum	Cotton	Sorghum.
4 Cotton	Bengalgram	Sorghum.
5 Fallow	Cotton	Fallow.
6 Sorghum	Sorghum	Sorghum.

The experiment was intended to continue for twelve years to get four cycles of rotation. It was later noticed to be defective in not having a similar series for all crops used in the rotation. Hence another series was started in 1941–42 so that effect of the same season on sorghum and cotton might be studied. The results obtained during 1940–47 showed that sorghum yields followed the sequence of gram, sorghum and cotton in the order mentioned during the normal years. In seasons of heavy rainfall there was nothing to choose between sorghum and cotton as preceding rotational crops. In the case of cotton, sorghum was the best previous crop followed by gram, fallow and cotton. In wet seasons, the fallow series recorded fall in yields while sorghum and gram were not different. Cotton after cotton remained the poorest throughout. The yields of sorghum and cotton in the three course of rotation were always better than the two course sorghum-cotton. Various experiments to evaluate the different rotations practised in the 'Tinnies' tract were conducted at the Agricultural Research Station, Koilpatti, and the following conclusions were arrived at. The yield of a cotton after a pulse is the best, the increase being as much as twenty per cent on the average but the practice does not appear to be economical if the nett monetary returns from the two crops are taken into consideration. Cotton after a bajra crop yields better than that after fodder sorghum, the difference being as much as sixteen per cent, but in droughty years the deleterious effect of fodder cholam is not seen. Cotton grown year after year on the same land depresses its yield by about twenty-three per cent but not further. The average yield of cotton in a four course rotation is as good as in a two course rotation of bajra followed by cotton, a very useful finding which can profitably be advocated to the cultivators.

Sorghum effect.—The usual rotation on the rainfed black soils of the 'Tinnies' area is the four year one of sorghum–cotton–bajra–cotton. It is commonly experienced by the farmers of this

tract that cotton grown after sorghum is pale in appearance, shorter in growth and less in yield than the one succeeding *bajra* crop. A survey of the yields of cotton for about thirty years revealed a loss of 16 per cent in the farmers' money crop which should be deemed greater than what could be generally made good by the cultivation of improved varieties. Research on this problem of *sorghum* injury on the succeeding cotton was taken up during the years 1931–37 at the Agricultural Research Station, Koilpatti, as part of a scheme financed by the Indian Central Cotton Committee. When a clear insight into the nature and causes of the phenomenon became available it was seen that (i) the diminished yield of cotton obtained in the tract on fields cropped with *sorghum* during the previous year is caused neither by lack of soil moisture nor by exhaustion of soil nutrients nor even by the presence of toxic products of decomposition; (ii) seed setting and duration of *sorghum* influence the intensity of the deleterious effects of *sorghum* cropping. The ill effects are not seen before shot-blade, but only after seed setting; (iii) the harmful effects cannot be removed either by the application of manures, or by the reduction of plant population or by mixing the sorghum with pulses; (iv) the effect lasts only for a single season; (v) the growing of both *bajra* and sorghum disturbs the exchangeable sodium ion contents of the soil, but they differ in the pattern of their rise and subsequent fall. In soils cropped with sorghum the rise of replaceable sodium is greater with the growth of the crop but its later decline is much slower than what is observed in the case of *bajra* soils. As a consequence, the sorghum soils are left more alkaline at the time of cotton sowing, which condition seems to be responsible for the lower yield; (vi) Correctives for alkalinity were tried for three seasons but they could not give conclusive results owing to unfavourable seasonal conditions. It was inferred that their application in the lower layers might show better response; (vii) Ploughing experiments showed that these soils were not benefited by cultivating them either prior to or after the sowing of cotton. A saving in the cost of cultivation might be effected by reducing the preparatory cultivation to the minimum; (viii) sorghum could not be replaced by other fodders; and (ix) thick sowing of cotton improved the yields of cotton in sorghum plots both in good and poor seasons of rainfall.

Mixed cropping of sorghum-indigo corrected the ill effects and the yield of succeeding cotton was raised to the level obtained after a *bajra* crop. Preliminary observations showed that there were plenty of root nodules of indigo and the quantity of nitrogen added to the soil might be estimated at twenty pounds per acre when a twelve pound seed rate for indigo was adopted. A wholesale extension of this practice in the districts of Tirunelveli and Ramanathapuram will wipe out the production deficit arising out of sorghum injury and increase the normal acre yields of the tract by ten pounds of lint over an area of 3·5 lakh acres.

Rotation experiments conducted at the Agricultural Research Station, Nandyal, revealed that a three course rotation of cotton-groundnut-sorghum was more economical for the tract than the time-honoured two course rotation of cotton-sorghum. The question of trials with legumes either as pure or mixed crops in rotation with cotton has been reopened in view of their beneficial effects on soil fertility and cotton yields, as also contribution to the food for man and cattle. It was generally noted that the applications of phosphates increased not only the yield of legumes, but also persisted in their effects on succeeding crop. After a detailed review of past trials on legumes preceding cotton a scheme for further experiments has been drawn up. They comprise of the following preceding crop mixtures to cotton :—

(*a*) Sorghum—Cluster beans at Coimbatore.
(*b*) Cereal—Indigo in Tirunelveli.
(*c*) Sorghum—Groundnut sorghum—Red-gram in Guntur.
(*d*) Sorghum—Indigo and groundnut at Nandyal.

Mixed cropping.—In 1941–42 an experiment was started at the Cotton Breeding Station, Coimbatore, with a view to find out whether the incidence of cotton stem weevil could be reduced by growing Cambodia cotton mixed with *ragi*. The results obtained showed that the device was ineffective against the weevil attack. But this experiment gave a new suggestion. The monetary returns from *ragi* cotton mixture were higher than the values realized from pure cotton crop. Further trials with variations in the proportion and mode of planting proved that the association of *ragi* in any form was more remunerative than the cultivation of pure Cambodia. Hence it was thought best to restrict the trial to the cultivation of cotton-*ragi* mixture with the usual spacing given to them when grown independently. *Ragi* was transplanted in beds and cotton dibbled in rows later at the time of giving the life irrigation to ragi. The after-treatments were common till the harvest of *ragi* crop and thereafter cotton was earthed up and irrigated in furrows. The results judged on the basis of net profit per acre proved cotton *ragi* mixture to be more remunerative than pure cotton. The same mixed cropping is being recommended as a means of stepping up cotton production in the irrigated summer *ragi* and groundnut areas and irrigated winter *ragi* zones of Madras State planted during September and October months. The data collected in the year 1950 indicate that yields ranging from 110 lb. to 475 lb. of seed cotton per acre can be obtained by growing *Uganda* 1 cotton on ridges between beds.

Chillies crop in Circars is subject to damage by *thrips* often resulting in total loss. Mixed cropping with cotton spaced five and half feet by nine feet served as an insurance against failure of chillies in good as well as adverse seasons, cotton contributing its quota of money value to the total economics. Cotton gave an average yield of 40 pounds lint in any year and more than compensated for the slight fall in chillies yield. It is a very useful

recommendation for the usually heavily manured rainfed chillies tract subject to severe *thrip* attack.

Reports of serious damage by *aphids* are common in the unirrigated groundnut crop of Circars and Ceded districts. In the Cocanada tract where the cotton crop is usually retained till mid-April after the harvest of groundnut in October–November, mixtures of red cotton and groundnut are fairly common. Trials were laid at the Agricultural Research Station, Guntur, during 1948–49, to find out whether mixed cropping of early cotton types would be more advantageous than red Cocanadas, as late drought and cattle trespass often pulled down the yield levels. Cotton varieties from Madras, Bombay and Uttar Pradesh were sown mixed in the proportion of one to every eight rows of groundnut in June–July. The cotton completed the harvests by December—a month later than groundnut crop and did not reduce appreciably the yield of the major component. The gross monetary returns from mixed crop was very much higher than pure groundnuts. Good quality cotton of 25/32 inch staple yielding up to 100 pounds lint per acre was obtained from good fields. The experiment indicated the possibility of fitting in an early white cotton variety in Circars and Ceded districts where nearly twenty million acres are annually cropped with groundnuts bunch or spreading type on fairly light soils. Similar scope also exists in other districts where the late sowings are adopted for growing it mixed with 'Cambodia' or Karunganni varieties.

Legume mixture.—Legumes occupy a subsidiary place in the farming system of Coimbatore district and do not figure in the garden land cropping under well irrigation. The rotation experiments on Cambodia cotton conducted at the Cotton Breeding Station, Coimbatore, during the earlier years of 1930–34 showed that the yields of cotton following sunnhemp, groundnut or fallow were always more than those recorded after sorghum, bajra or ragi. The practice could not be recommended since groundnut required more water than summer sorghum and since the differential effects were not noticed on soils having slight alkalinity. Fallow and sunnhemp for green manure were impracticable systems as no farmer would lose a cereal crop. Hence cluster beans in association with sorghum was tried among other pulses like greengram, redgram and cowpea. There was a depression in yield of sorghum when mixed with pulses other than cluster beans. The aftereffects on succeeding cotton were however not fully determined. The experiment was therefore reopened in order to assess the yield increases obtained in the succeeding cotton and to make a general recommendation to the farmers of the district, adopting sorghum-cotton sequence. The results supported the previous findings that sorghum was not affected in mixed cropping and that cotton appreciated slightly in yield.

Varietal mixture.—A mixture of *karunganni* and *uppam* is usually grown by the ryots of the 'Tinnies' area. In order to

find out the efficacy of such a varietal mixture, experiments were conducted at the Cotton Breeding Station, Coimbatore, during the years 1938–42 with pure *uppam*, pure *karunganni*, mixtures of *karunganni* and *uppam* obtained from the ryots and also artificial mixtures in definite proportions. The results conclusively proved that the sowing of either pure *uppam* or a mixture of *karunganni* and *uppam* was less remunerative than the growing of pure *karunganni*. Obviously the growers of such a mixture are misled by the showy appearance of a certain proportion of hybrids thriving in such mixtures. Another interesting finding in this experiment was that in such a mixture, *uppam* had a better survival value than *karunganni*.

Mixture of strains.—On account of the simultaneous spread of strains *Cambodia* 3 and *Cambodia* 4 in the Ramanathapuram district, natural crossing was found to take place and crop census taken in ryots' field during 1945 disclosed the existence of off-types of such inter-strain hybrids ranging from 13 to 33 per cent. These hybrids were variable in staple and weak in strength. The hybrid families synthesised from this cross were also found to be very neppy and considered commercially unsuitable. This observation on the deterioration in quality through hybridisation, when two pure improved strains of the same species possessing more or less identical fibre properties and spinning qualities were allowed to grow in a mixed state, brought out the fact that any recommendation involving mixtures of strains derived from different hybrid origins must be based on extensive studies on quality and performance in later generations.

FUNDAMENTAL RESEARCH.

The following aspects of fundamental research on the botany, physiology and genetics of the cotton plant were taken up and useful information added to our existing knowledge :—

Developmental studies.—As a preliminary to the study of bud and boll shedding in cotton, the development of Cambodia variety and a hybrid derivative of *Cambodia* × *Bourbon* was studied for three seasons. The development of the cotton plant at Coimbatore was essentially the same as those found elsewhere. The plant produced two flushes of buds and flowers and gave typical bimodal curves. The number of buds produced per flush was found to vary with the season and flush. The interval from bud to flower decreased from thirty-five days at the beginning of the first flush to twenty-five days at the beginning of the second flush and remained stationary till the end, when again it began to lengthen. The interval from flower to boll shortened from about sixty to forty days between December and April while it lengthed later. These periods were correlated with rise and fall of atmospheric temperature. Only five to seventeen per cent of the buds matured into bolls depending on the season and flush. Among them the buds produced from mid-December to end January were the most

efficient in developing into bolls. Although both buds and bolls shed, the loss in the former was greater than the latter in the first flush while the position was reversed in the second flush. Very young buds were the most liable to shed and the susceptibility decreased progressively after fourteen days. In the case of bolls this critical period ranged from seven to twelve days after flower opening.

Locular composition.—A study of the locular composition in Cambodia cotton was undertaken with two strains. There was a seasonal fluctuation in the stigmatic composition of the flowers produced on the same plant. Five locked bolls were generally produced early in the season. There was a greater percentage of shedding in the case of bolls formed from flowers with five stigmatic faces. A positive correlation was found between the number of five locked bolls and the remaining number of bolls produced by a plant and the regression lines were found to be linear. There was a negative correlation between the number of ovules per lock and locular composition. Yet, the total number of ovules in a five locked boll was greater than in a four locked boll. Variability in number of ovules was greater in a five locked boll than in a four locked boll. Locular composition did not interfere with setting or maturation period. The *kapas* weight per seed was least in a five locked boll and highest in a three locked boll.

First fruiting branch.—A study of the position of the first fruiting branch and at different environmental conditions disclosed that the nature of the previous crop in rotation, manure applied, cultural operations during the season and time of sowing exerted a significant influence on the expression of this character.

Leaf growth.—The object of the study was to discover the relationship, if any, between the age of leaves and productivity with the several varieties of cotton. It was observed that the leaves borne at the lower and topmost nodes were shorter lived than those produced in the middle zones. It was interesting to find an association between the rate of movement of total nitrogen and leaf age and if the nitrogen was transported more quickly, the leaves tended to drop earlier. The development of the leaf was most rapid in the first ten days after unfurling and was practically nil after thirty days. The existence of varietal differences in age, position, nitrogen content and rate of growth was established.

Opening of corolla and anthers.—A study of anthesis in cotton revealed that though the time of opening was mainly conditioned by the atmospheric temperature and humidity, varietal differences were distinct. Generally the American types were earlier than the Asiatics in the opening of both corolla and anthers. The anthers usually burst before the unfurling of the corolla in the exotic as also in some of the indigenous cultivated races of *bengalense* and *Cernuum* in *G. arboreum* and *G. herbaceum* var *accrifolium* in contrast to races like *indica* and *soudanense* in *G. arboreum* and *G.*

hirsutum var *punctatum* where the bursting of anthers occurred after corolla opening. The time of anther dehiscence was found to be considerably earlier in February-March than that in December-January.

Variation in number of anthers.—The chief indications in this study were that the American types had a greater number of anthers than the Asiatics. The range was 72–134 in the former and 47–90 in the latter while there was a general tendency for the number to increase as the season advanced.

Contabescence of anthers.—Enquiry conducted during 1929–31 with two '*Karunganni*' pure lines revealed that the percentage of contabascent anthers per flower was found to exhibit a periodic seasonal fluctuation. The early formed flowers were prone to contain a much higher percentage than later formed ones due to the prevalence of higher temperature during the former period.

Flower shedding, motes, mis-shapen boll development and imperfect boll opening were some of the serious defects noticed in the cotton crop raised in Palur. Preliminary observations made during the summer of 1945 showed that contabescent anthers were the primary cause. Systems of rotation, mixed cropping, or soil correctives failed to influence or lessen the shedding loss. Applications of nitrogen, phosphoric acid, boron, potash and lime had no effect either on contabescence or ultimate seed cotton yields. Varieties having an early flowering habit suffered comparatively less than others which were late. The pollen teased out from contabescent anthers were shrunken and ill formed. They stained brown with iodine, failed to burst when mounted in water and appeared vacuolate. Such abortive development must have resulted from adverse environment at the time of tetrad formation. Meteorological records and the incidence of sterility were studied on the time scale and it was found that the period of greatest occurrence coincided with the prevalence of higher maximum temperature (100° F.) and low humidities during the bud stage. It was therefore concluded that high temperature during pollen formation was detrimental to normal development and resulted in contabescent anthers. All varieties American and *desi* including wild cottons reacted similarly and any sort of varietal tolerance or resistance did not exist. Agronomic measures like shifts to an earlier planting date, frequent watering, close spacing and wind belts were tried for ameliorating the ill-effects of atmospheric temperature and humidity. December planted crop dodged the high temperature period and recorded yields over 3,000 pounds seed cotton which was thrice as much as March planted crop. The increase in yield was traceable to both increase in flower production and decrease in flower shedding arising out of contabescence. Irrigations at five day intervals reduced considerably the flower shedding possibly on account of an induced milder microclimate in such treatments. Plants screened with *thatties* and protected from dessicating winds did not suffer to the same degree as the plants kept in the open.

All varieties of American and *desi* cottons broke down when the critical temperature of 100° F. was reached. Senescence bore no relation to the degree of incidence. The time lag of about a month noticed between the rise of atmospheric temperature and appearance of contabescence would possibly indicate that the deleterious effect was on tetrad formation and cell division.

The germination of seeds obtained from Palur cotton was generally very low of the order of 30 per cent. The seeds when examined were found to contain ill-filled and hollow seeds up to 60 per cent. Enquiry at the ginneries and villages showed that the cultivators of South Arcot were aware of the poor viability of seeds produced in that tract and invariably used the imported seeds from the neighbouring districts. The embryo was often found ill-developed and discoloured. The mean weight of seed coat in good and hollow seeds were the same while the contents in the two widely differed depending on the soundness of the seed. It was a case of arrested development of the embryo similar to pollen abortion. Manures and varieties did not exert any influence on the occurrence of hollow seeds with poor viability. It is probable that high temperature at micro or megaspore formation is detrimental to their normal development. The harvests of early sown crop contained less motes, low proportion of bad *kapas* and high percentage of well-filled and viable seeds, while the converse was noted in late planted crops. It would therefore be advantageous to sow early in December and use the harvests collected up to mid May for seed purposes.

Pollen viability.—Immature flower buds due to open in a couple of days were sent by post packed in cellophane rolls over a distance of 275 miles involving a time interval of 44 hours. The pollen from these transported buds were dusted on to the emasculated normal flowers at the other end. The boll setting was 13 per cent of the total number of crosses made and the contents of such developed bolls were quite normal. The methods will be quite useful in breeding programmes involving intensive hybridization between geographically isolated races or species differing in periodicity of flowering.

Boll studies.—Studies undertaken with regard to the development of the boll and its contents in Cambodia revealed that the carpel was the first to cease growth, the testa continued to grow only for a few days more and the lint developed till the end of six weeks. It was only the embryo that added to dry weights till the day of opening of the boll.

Seed coat permeability.—A physiological study of delayed germination in cotton traced the cause to impermeability of the seed coats in the hybrid material. Further experiments confirmed that the micropyle which was the channel for water intake in normal seeds failed to function and the absorption took place only through the seed coat. It was also noticed that the existence of empty spaces due to ill-filling of the seeds in these hybrids, acted

as a great handicap in the absorption of moisture, as also the supply of requisite mechanical force for rupture of the seed coat.

Water requirements.—Studies on the water requirements of Cambodia cotton were made for six seasons both in field and under pot-culture conditions. The requirement of water calculated on the basis of yield of *kapas* was best at 30 per cent level while that calculated on the basis of dry matter was best at 40 per cent level. Two irrigations given at four weeks interval in the months of December and January were found to produce the most profitable yield. Irrigations given at regular intervals of one, two or three weeks were wasteful. The fifteenth, eighteenth and twenty-first week after sowing were found to be the critical periods requiring more water.

Drought Resistance.—Determinations of leaf water contents at different periods of growth revealed that *uppam* contained more percentage of water than *karunganni*. However, no appreciable differences were noted between them in the osmotic pressure of root and tissue fluids of leaves indicating that the greater drought resistant capacity of *uppam* was not caused by such differences alone. Root studies indicated that *uppam* had a deeper root system than *karunganni* which explained the comparatively higher drought resistance of *uppam*.

Studies in root respiration.—It has been experienced that most of the attempts made to grow Cambodia cotton in rainfed black soils generally ended in failure. It was thought desirable to investigate the probable causes. The first enquiry that suggested itself was the comparison of respiration rates between Cambodia and indigenous cottons. It was stated by other workers that respiratory activities of higher plants are dependent on the content of hexose sugars in their roots and the data obtained here showed that more sugars were present in the roots of Cambodia than in those of *uppam*.

Floral anatomy.—The anatomy of the flower with special reference to the organization of the vascular skeleton in the gynaeceum was studied in detail during the years 1932–37 in all the important cultivated varieties and in four wild forms of both the old and new World groups of cottons. Distinct differences were observed in the pattern of arrangement of the vascular bundles in the thalamus and gynaeceum of different varieties which were deemed as useful criteria for the classification of the cultivated cottons. They were divisible into five main groups, viz., three in new World corresponding to *G. hirsutum*, *G. religiosum*, and *G. barbadense* and two in old World agreeing with *G. aboreum* and *G herbaceum*. Pattern was Mendelian and simple in inheritance, wild pattern being dominant over cultivated.

Pollen tube.—With the object of finding out the causes for the difference noted in the number of hairs on the seeds of a lock, a detailed examination of the ovules and seeds was made. It was

interesting to note that when once the pollen tube entered the ovule, it had the property of clinging on to the ovule even when the ovule was taken off the boll in early stages. This observation was very helpful in further studies on the rate of pollen tube growth and the order of fertilization. It was found that the pollen tubes penetrated through the conducting tissues of the style and exhibited strong chemotropism when they entered the ovarian cavity. In receptivity, ovular positions three, four and five reckoned from the top were earlier than others.

Origin of lint and fuzz.—The study was undertaken to find out the causes on the fundamental differences between lint and fuzz hairs. Microscopical examinations of the ovular sections of different varieties disclosed interesting difference in origin and development of lint hairs. These studies showed that fuzz hairs were sub-epidermal while lint hairs were epidermal in origin and they reacted differently when treated with a strong solution of cupr-ammonia. The sections from lintless and fuzzy seeded types confirmed the above finding totally. It was also found that the size of the respiratory cavity behind the stomata found on the seed coats had a bearing on the production of fuzz and that the seeds in the middle of a lock possessed the least amount of fuzz.

A study of the formation, development and functioning of the stomata on cotton ovules in different varieties disclosed them to be more concerned with respiration than with transpiration.

Observation on ovules indicated that the variation in number of hairs existed even before fertilization and fresh crops of hairs were produced during boll maturation and the leaf hairs also behaved similarly.

Variation in seed and lint weight.—Observations disclosed that the seed and lint weights decreased as the season progressed and that there was some relation between these characters and position of the seed in a lock.

Parthenogenesis.—The production of a cross between American and Asiatic cottons was attempted at Coimbatore in the earlier years (1922–26). The Asiatic variety was invariably used as the maternal parent. The pollen of G. *hirsutum* supplied the necessary stimulus for the growth of the ovary till about the nineteenth day when the development of the boll was almost over. A small percentage of setting was noticed in G. *indicum* and the few bolls that happened to be the outcome of parthenogenesis were much smaller in size and contained only one or two seeds. Pollen from (*hirsutum* × *raimondii*) hexaploid induced parthenospermy in Asiatic varieties up to seven per cent. In crosses effected with pure *arboreum* and interspecific first generation (*arboreum* × *herbaceum*) hybrids, the resultant progeny was similar to the parent in the plant morphology and seed characters. A practical use is being made of this finding by inducing parthenogenesis in types and crosses which are desirable in other respects. A successful

exploitation of this method will shorten the period required for purification by several generations.

Lint maturity.—Studies with regard to the immaturity of the hairs revealed that shorter fibres in " Karunganni " contained higher per cent of immature hairs while Cambodia showed a larger proportion of unripe fibres in the longer group lengths.

Lint colour.—The " Coconadas " cotton is generally more valued for its colour and studies on lint colour disclosed the following features. During the period of boll maturation, the colour development commenced about a week prior to boll dehiscence. Mature lint developed its full colour in the short period of one week and the colour expression of mature bolls removed from the plant and exposed to sun was quicker than those retained on the plant. The storage of lint during a period of eight months did not materially change the original tint. The deeper tint was closely associated with the shorter staple and coarser fibre. There was apparently no relation between depth of colour and dye absorption. Fineness as reflected by fibre weight was closely associated with high dye absorption but the property had no relation to the ultimate tint. A study of the environmental effects on colour has been taken up.

Germination.—In order to obtain cent per cent stand in experimental area, the method of dibbling accessory seeds of other crops having quick germination in the same hole as cotton and covering them with either earth or sand was compared with the planting of cotton seeds only. It was observed that when bengalgram or lab-lab or groundnuts or Uppam cotton was used as associates in the same hole, the germination of Cambodia was improved by five per cent. If sand was used for covering the seeds instead of soil, a further increase of five per cent in germination was effected. In another set of experiments, the seeds obtained from season and summer picking were tested for germination and growth. Yield figures revealed no differences within the same variety provided adequate safeguards were adopted for creating a good stand of the crop by use of either sound seeds or higher seed rate.

Water absorption of germinating seeds.—A varietal study including *Cambodia CO.2, Uppam 2405 and Karunganni C.7* revealed the existence of two distinct phases of water absorption during germination. The initial phase of absorption is slower and its rate is dependent on the availability of moisture in the surrounding medium and is independent of the varieties. In the second phase the absorption is accelerated and is influenced both by the nature of variety and level of moisture. In all the varieties tested there was a considerably long period extending up to 28 hours at its maximum during which the process of germination consisted in nothing but an osmotic intake of water.

Seed storage.—In order to find out the period up to which cotton seeds could be stored without reduction of viability, four

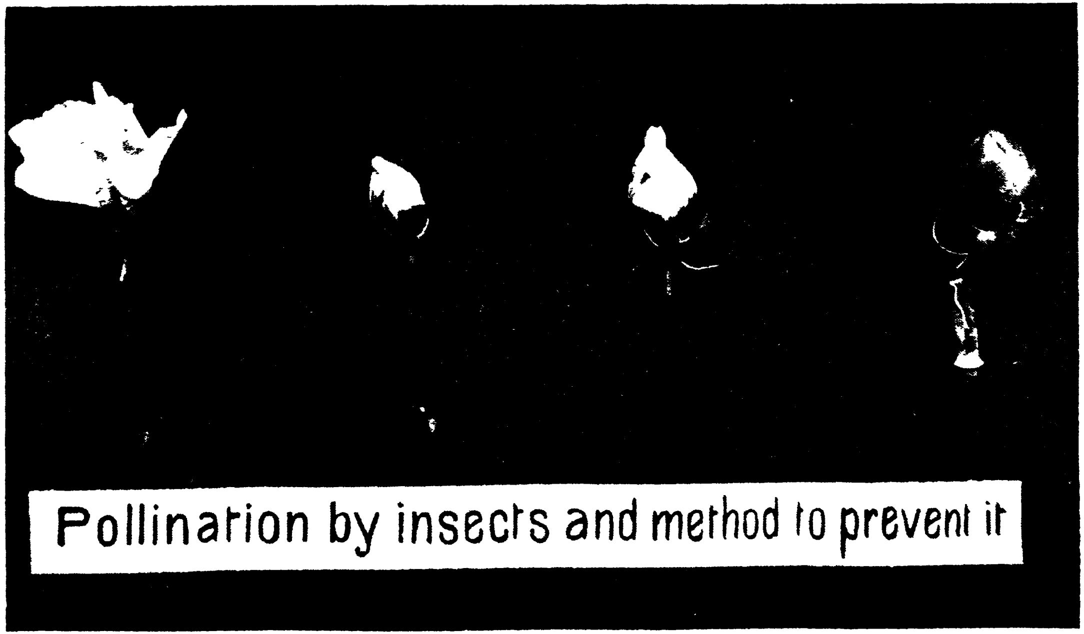


Plate 83.

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Plate 84.—*Selfing in cotton—A cheap device.*

P. 544

methods of storage involving stocking in single versus double gunnies and monthly drying versus no-drying were tried using all standard cotton strains. Samples were drawn every month for testing germination. The data collected for one year revealed that there was neither progressive increase or decrease in the percentage due to time lapse even though the monthly means differed significantly. The variations are attributable to factors like changes in air temperature, humidity, soil temperature, etc. No differences between single and double gunny or systems of drying were noticed.

In another experiment to find out the effect of pressure on the viability of cotton seeds stored in twelve layers, it was found that the bottommost layer recorded a germination percentage of 59 only while samples from the other bags recorded 77 to 85 per cent. The lower germination of the seeds from the bottom most layer is ascribed to the mechanical pressure of the eleven bags above it and the hard floor below. A thick layer of sand at the bottom and stacking upto six bags are suggested as remedial measures.

Quality deterioration studies.—Deterioration of quality in Cambodia cotton was expressed in 1934 and degeneration studies on *Cambodia* 2 revealed that the cry was ill-founded. The trend of lint length was examined for ten years from 1924 to 1934, but no decline was perceptible.

Cheap selfing device.—Stitching the cotton bud before they would open was the common method employed to prevent cross-pollination. Various methods were tried for quickening and cheapening the process. Of the several methods tried, gumming failed when the buds were big in size; glue though suitable for the purpose had to be kept warm to prevent it from drying; and lint dipped in gum applied on the tips of flower buds proved very efficient. Clay, later substituted for gum, proved equally successful and its cheapness and ready availability were definite advantages over all the others. This method has been introduced in all breeding stations and has considerably kept down the cost of material used for selfing.

Induced mutations.—Research on this item was taken up with the idea of producing progressive mutants useful for breeding. This was sought to be achieved by exposing dry and germinating seeds to X-rays, dry seeds and young seedlings to Rontgen rays, by subjecting to heat or low temperatures and by centrifuging the seedlings. No progressive mutants were obtained. However, three recessive mutants—two chlorophyll deficient and one meristic—and one dominant single lobe leaf mutant were found to occur in the second generation.

Cleistogamy.—A cleistogamous mutant was spotted in an interspecific hybrid during the year 1948. The petals having a natural cleft at the broad top get interlocked in the normal aestivation. The character would be extremely useful if it could be

employed in flagging all the improved American cottons so that contamination and deterioration through vicinism could be totally prevented and the present expenditure and care bestowed in self-fertilisation avoided. Being a recessive character, detection of off-types in the field would also be very easy.

Variation in Mendelian Ratios.—The cotton bolls are normally gathered for six weeks during which period it is possible that the wide fluctuations occurring in the environment may influence the proportion of different kinds of gametes formed and affect the Mendelian ratios recorded in the early and late harvests of the F1 hybrids. A simple character like flower colour and easily identifiable genotypes like female sterility and super-numerary condition of the floral parts were studied. The data collected showed that the time of production of bolls had no influence on the mode of segregation.

Heterosis.—Hybrid corn is possibly the only outstanding example in the field of practical utilisation of heterosis in crop improvement. The preliminary experiments on heterosis in cotton involving interspecific crosses of *hirsutum* and *barbadcnse* revealed heterotic effect in staple length, fibre weight and spinning value in the irrigated series (*Cambodia* x *Egyptians*) and seed cotton yields in the unirrigated trials (*Cambodia* x *South American* perennials).

Experiments conducted on arboreum x herbaceum hybrids revealed pronounced heterosis in plant height, yield of seed cotton and lint length. An intervarietal, inter and intraspecific crossing programme covering the four cultivated species, viz., *G. barbadense*, *G. hirsutum*, *G. arboreum* and *G. herbaceum*, was put through in 1948–49 for a comprehensive study of heterosis in cotton and exploring the possibility of utilising outstanding combinations for extension work.

Vegetative propagation of cotton.—The problem of high cost of hybrid seed was against the exploitation of hybrid vigour in the same manner as maize by harnessing heterosis for increased production. Experiments were therefore conducted on the vegetative propagation of stem cuttings in order that the hybrid stock plants might be used in the same manner as horticultural types. Synthetic plant hormones which induce rooting in subjects normally failing to root as cuttings, were used to treat the first generation hybrids. The commercial products Seradix A and Seradix B (three forms) were employed in strengths and time intervals recommended by the manufacturing firms. The observations showed that the cells at the cut ends exhibited tendency to produce a larger number of rootlets, and the shoot-growth developing from treated cuttings were more than the untreated control. Seradix B_2 was found to be the best for cotton. The growth and yield of such treated cuttings were found to be satisfactory. Experiments on a field scale were equally

Plants raised from cuttings.

Plants raised from seed.

Plate 85.

encouraging in that thick size cuttings from main stem possessed as much growth and productivity as seed planted crop.

Genetics.—The inheritance of dwarf characterised by shortened internodes was simple. The genetics of the character-position of the first fruiting branches studied in two crosses indicated multiple factor hypothesis. A single pair of factors controlled the segregation of crinckled leaf mutant. A twisted leaf curl mutant found in *I* x *C*99 behaved as a recessive to normal *G. arboreum*, but was subjected to modifier effects in *G. herbaceum* crosses. Two mutants, one with practically no ovary or boll and the other with bolls with single lock behaved as monogenic recessives to normal. It was interesting to note that these mutants tended to bear a fewer number of petals, which were inherited independent of genes affecting leaf lobing and flower colour. Lintlessness and glabrous ness were found to be recessives to linted and hairy respectively. Lintless hairy and lintless glabrous were complementary yielding a ratio of two to one for linted and lintless types. The behaviour of petalody followed the law of blending inheritance with incomplete dominance in F_1. The meristic variant obtained as a result of exposing pollen to X-ray was a simple recessive to normal. Segregation of the colour of pollen was studied in both intervarietal and interspecific crosses in two Asiatic cottons, viz., *G. arboreum-race indicum* and *G. herbaceum* var *acerifolium*. Buff pollen behaved as a recessive to yellow pollen. Three factors were found to control the inheritance of lint colour in Asiatic cottons. The behaviour of two chlorophyll deficients, viz., xantha and albino was simple but the albino was epistatic to xantha when both occurred together. Studies on the inheritance of fan and filament colour were inconclusive as seasonal and diurnal variations were noticed to influence their expression. The study of inheritance of three new characters found in the survey of the Cocanada area showed that fibre " immaturity " was a simple recessive to " mature." Ghost petal spot was homologous with R_2 O^s described by other workers and its occurrence in a new tract supported the theory of Godavari district being a possible secondary centre of origin for *arboreums*. The new type of incomplete boll dehiscence was a monogenic recessive to normal and behaved as complementary to Wagad type of boll opening. The inheritance of lint colour in *Cocanada's* cotton was studied and adequate information on the lint colour status of the *Cocanada* area was gathered. In the study of genetics of four " dwarf " mutants in *indicum*. " *Coimbatore dwarf* " behaved as a monogenic recessive to normal in both *arboreum* and *herbaceum* crosses. " *Anakapalli dwarf* " was a simple recessive to normal while it behaved as complementary to " *Cocanada dwarf* ". " *Cocanada dwarf* " and " 1767 *dwarf* " represented independent mutations at the same locus. The character " *sparse lint* " which behaved as a simple recessive to normal, was yet another new addition from the highly variable Cocanada centre.

FIBRE TECHNOLOGY.

Raw cotton is valued in trade for its quality which is largely determined by fibre characters. The cotton work in Madras has therefore included in its programme the improvement of quality and a technological section working under the Cotton Specialist, Coimbatore with the financial assistance of the Indian Central Cotton Committee provides for the close liaison between the Technological Laboratory, Bombay and the cotton breeder in all stages. Routine tests on the cotton fibre by the standard methods are carried out and selections based on mean staple length, fibre maturity and fibre weight are normally made at the several cotton research stations of the State. In addition to such routine tests, other fundamental aspects of fibre technology have been tackled from time to time. The following in brief summarises the results obtained so far :—

Variation in the measurable characters of cotton fibres.—A systematic study of the variations within a seed, between seeds in a lock, between locks, between bolls, between weekly pickings, between the first and second flush of bolls, caused by irrigation, spacing, rotation, manurial treatment, place of growth, between length groups and between maturity classes of fibres was made. The results disclosed the existence of large variations on the seed surface. Although there appeared to be some differences between the seeds in the locks, the variation due to the composition of the locks and bolls was not appreciable. The age of the plant influenced the variation. The difference between the weekly pickings, however, was not large except in the end pickings, but between the season and *kar* flush of bolls it was considerable. It was also seen that irrigation, spacing, rotation and manurial treatments did not induce any large variation. The influence of climate taken as a whole appeared to be appreciable, judged by the difference within a tract when the seasonal factors fluctuated considerably. Temperature and solar activity were the main causal factors. The general trends were towards a large variation within a seed than between seeds composing the sample indicating thereby that the heritable influence was bigger than the environmental effect. It was also found that (*a*) in a lock of cotton, the weight of lint composed mostly of cellulose was greatest in lower seeds near the source of food supply while the weight of embryo composed of proteins, fats and minerals was highest in the upper half situated farther from the source of food supply, and (*b*) the variation exhibited by a bulk sample of cotton was in no way greater than that present in a single seed of the same bulk.

The clinging power of cotton and the number of convolutions per centimetre.—In the course of examination of cotton obtained from weekly pickings, it was found that there was a large variation in the number of convolutions per centimetre. It had been found by other workers that the clinging power of cotton fibres depended

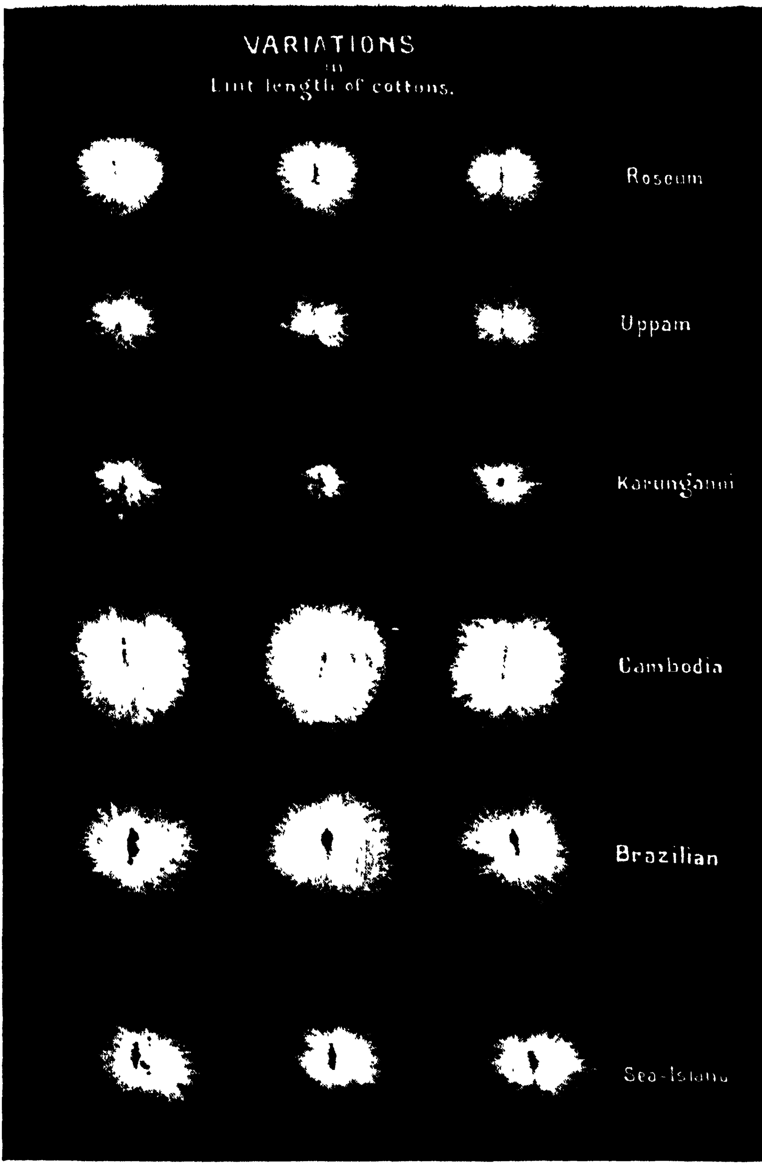

Plate 86.

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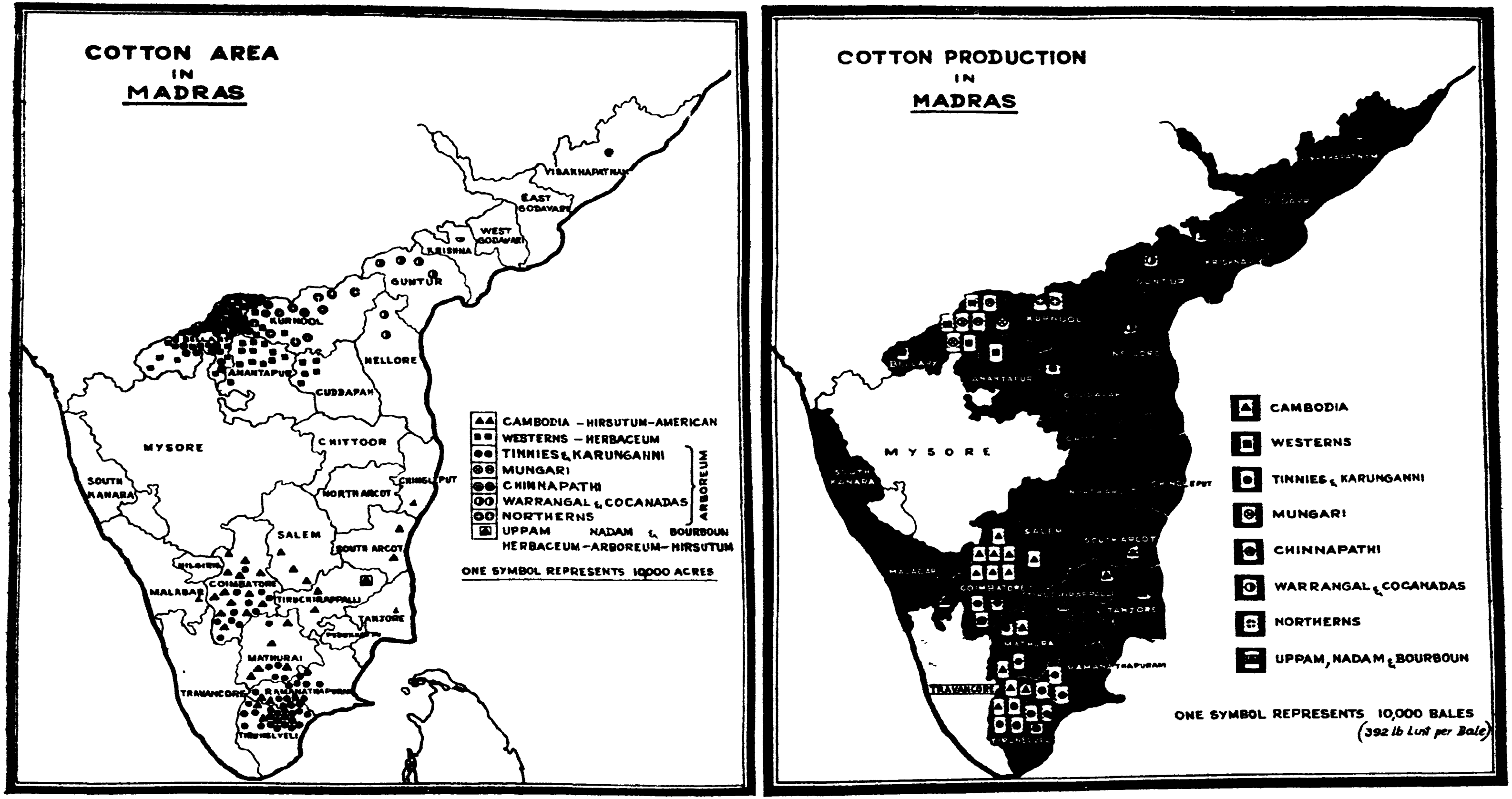
COTTON AREA
IN
MADRAS
VISAKHAPATNAM
EAST GODAVARI
WEST GODAVARI
KRISHNA
GUNTUR
KURNOOL
BELLARY
ANANTAPUR
NELLORE
CUDDAPAH
CHITTOOR
CHINGLEPUT
NORTH ARCOT
SOUTH ARCOT
MYSORE
SOUTH KANARA
SALEM
NILGIRIS
COIMBATORE
MALABAR
TIRUCHIRAPPALLI
TANJORE
MATHURAI
RAMANATHAPURAM
TRAVANCORE
TIRUNELVELI
CAMBODIA - HIRSUTUM-AMERICAN
WESTERNS - HERBACEUM
TINNIES & KARUNGANNI
MUNGARI
CHINNAPATHI
WARRANGAL & COCANADAS
NORTHERNS
ARBOREUM
UPPAM NADAM & BOURBOUN
HERBACEUM-ARBOREUM-HIRSUTUM
ONE SYMBOL REPRESENTS 10,000 ACRES
COTTON PRODUCTION
IN
MADRAS
MYSORE
SOUTH KANARA
MALABAR
TRAVANCORE
CAMBODIA
WESTERNS
TINNIES & KARUNGANNI
MUNGARI
CHINNAPATHI
WARRANGAL & COCANADAS
NORTHERNS
UPPAM, NADAM & BOURBOUN
ONE SYMBOL REPRESENTS 10,000 BALES
(392 lb Lint per Bale)

Plate 87.

IMPROVED DESI TYPES
MADRAS

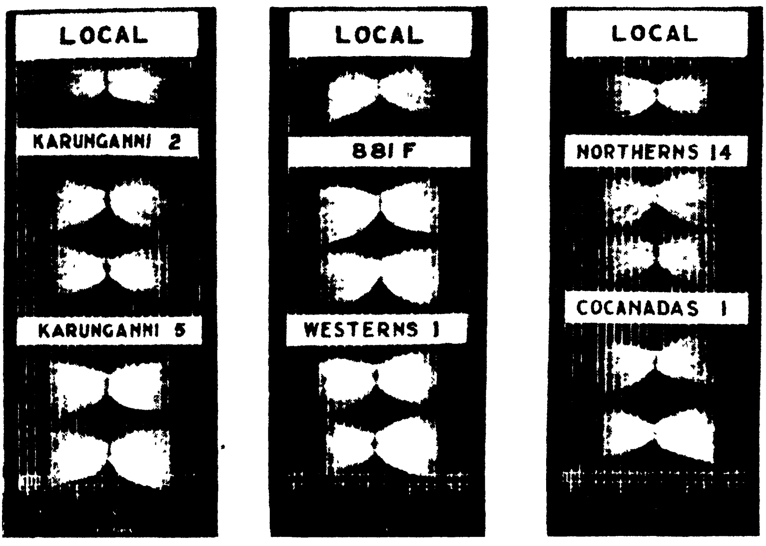

Plate 8b.

IMPROVED AMERICAN TYPES
MADRAS

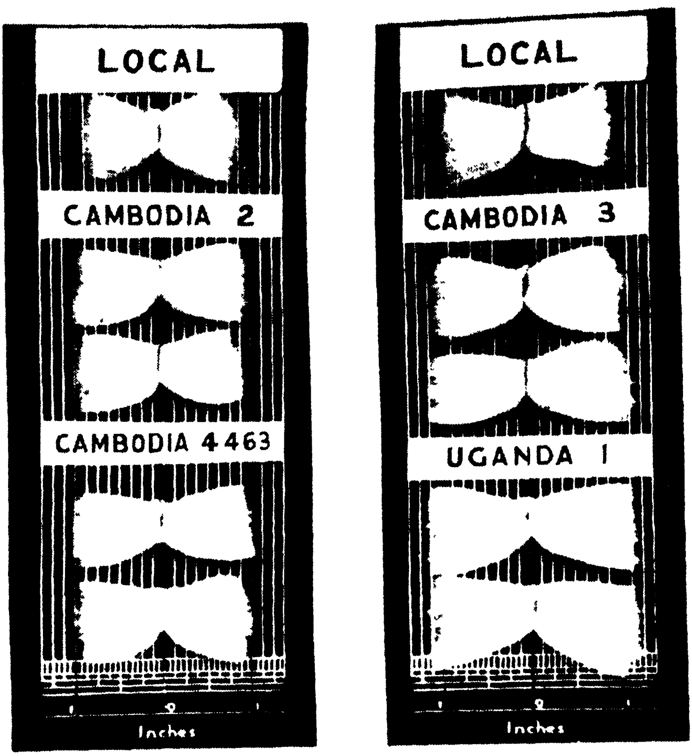

Plate 89. P. 554

upon such convolutions. Results of investigations on samples of *Cambodia* 2 drawn from weekly pickings revealed that (*a*) the clinging power was maximum when the samples of fibres for testing and forming the pads were drawn from the same lot but when the convolutions of the two were different, there was always a fall in the clinging power, (*b*) in consequence of the above findings the strength of soft twisted yarns tended to increase when cottons possessing nearly the same number of convolutions were selected for mixing, and (*c*) when the fibres for pads and tests were derived from identical samples, the clinging power bore no relationship to the convolutions indicating thereby the absence of correlation between yarn strength and the convolutions.

Number of fibres on a cotton seed.—The average number of fibres per seed was determined in two strains according to four different methods. The results indicated that, where considerable accuracy was not needed, the ordinary cutting method could be employed with a positive correction of two to three per cent. This method consisted in dividing the lint weight per seed by the product of the mean fibre length and the mean fibre weight.

HARVESTING AND YIELDS.

The practice of picking clean *kapas* from well dehisced bolls is prevalent to a large extent in the Cambodia and "Tinnies" tracts where the harvests are early. In parts of Salem district, fully ripe but partly dehisced bolls are harvested, dried and *kapas* extracted later. This method leads to deterioration in quality of the produce which is packed in a partly wet state. In the Cocanada area, sometimes the burst bolls are plucked with capsules and *kapas* leisurely separated in shade. The harvests are delayed in the westerns area due to dearth of labour at harvest time and consequently the produce dropping on the ground gets dirty and mixed with dried leaves and twigs. Similar defects also result from delayed pickings done during hot hours of the day. The propaganda done for clean picking cotton free from dirt and leaves, has not effected so far any change in the farming habits of dry land cultivators.

The normal yield levels of Madras cottons are presented in Statement No. 6.

STATEMENT NO. 6.

Variety.	Normal yield of lint per acre in lb.
(*a*) Irrigated cambodia—	
Coimbatore	300
Salem	250
Tiruchirappalli	275
Madurai	250
Ramanathapuram	300
Tirunelveli	250

Variety.	Normal yield of lint per acre in lb.
(b) Unirrigated cambodia—	
Coimbatore	125
Salem	100
Tiruchirappalli	100
Madurai	120
(c) Tinnies including Karunganni	103
(d) Uppam	65
(e) Nadam and Bourbon	20
(f) White and Red Northerns	50
(g) Westerns	50
(h) Warangal and Cocanadas	75
(i) Chinnapathi	50

The acre yields from irrigated cambodia in Madras compare favourably with those recorded in other irrigated tracts of India and two major cotton growing countries of the world.

STATEMENT No. 7.

Place.	Yield of lint per acre in lb.
Madras	271
Punjab	196
Sind	220
Mysore	200
America	267
Egypt	530

GINNING AND STORAGE.

The seed cotton harvested from the fields is usually stored in big gunny bags called *borahs*, but in seasons of brisk trade, the cotton is sometimes carted loose in open country carts to the ginning factories. The number of ginning and pressing factories in Madras which was 257 in the year 1923 has nearly doubled in the span of twenty summers and the actual number in 1946 is 484. Most of the cotton gins are of the roller type run on electric or oil power. The hand model country wooden gin is however used in remote villages where hand-spinning and weaving are still in vogue. Some of the ginning factories own presses also and the lint is usually stored for some time before being pressed into bales of 392 lb. nett. If the weather is unusually dry, water is sometimes sprinkled on the ground or directly on the cotton. Deliberate acts like mixing various varieties and qualities, cotton waste, seed and foreign matters are other malpractices prevalent during the processing stages in gins and presses. The Ginning and Pressing Factories Act (Act XXII of 1925) as amended recently seeks to prevent adulteration, watering and presence of seed or leaf above a specified proportion. The lint pressed into bales or kept unpressed is sold to the mills for consumption or to merchants for export. The seed is purchased by *mandies* for sale as cattle feed and sowing seeds. The cotton grower does not retain seed for sowing purposes

as he usually sells his produce as seed cotton. Except the enlightened ryots who use the improved seeds produced by the Agricultural department, the rest of the growers purchase bazaar seeds of daubtful purity for planting.

The cotton seeds are usually stored in *gunnies* and the bags stacked in layers. Experiments on storage conducted at Koilpatti have conclusively proved that for ensuring good germination, the bags should not be stacked in tiers exceeding six. A thick layer of sand spread on the hard floor prevents deterioration of the bottom layer of bags. Periods of storage up to one year did not affect germination percentage. No difference between storage in single or double *gunnies* was noticed provided restacking was done periodically.

Cotton seed and its feeding value.—In the pre-war period the cotton seed production of this State was roughly estimated at 2·0 lakh tons of which barely 16,000 tons were used for planting purposes, leaving the bulk of it for consumption as cattle feed. The post-war production figures have been fluctuating round about 1·25 lakh tons of seed due to curtailment of area under cotton. After meeting the needs for planting purposes, the rest of this quantity falls far short of the requirements for the twenty-two million heads of cattle in the State. Cotton seed oil is not extracted in India as yet, and the seeds serve as a rich source of concentrates for the ill-nourished livestock, the mainstay of Indian agriculture. Cotton seed has all along been recognized by the farmers as one of the most abundant sources of protein of very high quality. Any increase in cotton seed production will therefore help in building up a better health of Indian cattle. There is a belief current among ryots that the more fuzzy American is less nutritive than *desi* seeds, but it has been dispelled by nutrition experiments conducted elsewhere in the Punjab. The analysis figures for the seeds of improved varieties given below support the above findings.

STATEMENT NO. 8.

Variety.	Combodia 2.	Cambodia 4.	Karunganni 2.	Karunganni 5.
Moisture	7·45	7·31	8·00	8·10
Protein	18·37	20·13	17·19	16·94
Ether extractives ..	22·96	23·00	17·14	17·00

SEED MULTIPLICATION AND DISTRIBUTION.

The multiplication and distribution of improved seeds constitute the immediate extension work of breeding research. In a commercial crop like cotton, the quality standards built up in the improved strains can be kept up only if a high degree of purity is maintained at every stage. For such a purpose special organizations are necessary. The stages of multiplication in Madras are briefly outlined below. The seeds of improved strains which are evolved after years of breeding research and concurrent yield tests

in cultivators' lands are first multiplied in ' nucleus ' plots in the regional research stations. The cross-pollination is prevented by a process called ' selfing ' and any odd off types are removed. These seeds are multiplied in the second stage on what are called ' inner seed farms.' These are arranged on the lands of influential and trustworthy landlords who bind themselves to use the pure seeds sold by the department, to allow roguing of the crop by the Agricultural Officers, to gin the produce under departmental supervision, and to sell the entire seed back to the Agricultural Department usually at a small premium over the prevailing market rates. These seed farm ryots are also given small crop advances towards cultivation expenses which are recovered at the time of seed purchase. The seed from such inner seed farms are then distributed by Departmental staff to what are called ' outer seed farms.' The produce of the outer seed farm is carefully ginned under the same strict supervision and the seeds collected therefrom after cleaning are made available to the public as certified seeds. The seed farm ryots are also helped in the disposal of pure lint.

Special schemes for the multiplication and distribution of improved seeds have been initiated from time to time as and when improved varieties are released from breeding stations. The Indian Central Cotton Committee bear a portion of the expenditure in seed schemes during the first four years in order to make good seeds available at fair prices. The following are the several seed schemes that have been or are still operating in this State :—

(*a*) *The Madras Co. 2 Distribution Scheme.*—In November 1929 the Indian Central Cotton Committee sanctioned the Madras (Tiruppur) Seed Extension Scheme, the object of which was to provide for a period of five years, the pay of an officer to act as an adviser to a group of co-operative societies in Coimbatore district which was growing improved strains of Cambodia cotton and to help the Agricultural Department in their seed distribution work. The scheme started in 1931. In 1933, this scheme was amalgamated with Tiruppur Co. 2 (Cambodia) seed extension scheme sanctioned by the Indian Central Cotton Committee in 1932 for a period of five years for the distribution of Cambodia Co. 2 seed in Salem and Coimbatore districts through the agency of Madras Agricultural Department and the Tiruppur Co-operative Trading Society by organizing a seed multiplication area of not less than six thousand acres and distributing pure seed for one lakh acres every year. This scheme closed in 1937 after working for a period of six years. The area under seed farm and production of seed in 1932 and 1937 are given below :—

STATEMENT No. 9.

Year.	Actual area under seed farm.	Production of seed in maunds of 24¾ lb.	Sufficient to grow acres.
1932–33	1,739	19,944	20,000
1937–38	5,350	52,584	53,000

In January 1938, was sanctioned a skeleton scheme for another year to help the Tiruppur Co-operative Trading Society, which terminated in 1939. The work was later taken up under departmental auspices from 1941. Since the year 1949 a combined scheme for *Cambodia*-2 and *Karunganni*-5 is operating at Tiruppur for producing and distributing 10,000 bags of pure seeds of these varieties.

(*b*) *The Madras Co.* 3 *Seed Distribution Scheme.*—Cambodia cotton grown in Salem had a bad reputation and was quoted low in Tiruppur market. The quality of *kapas* and the viability of seeds were always at a discount due to the practice of harvesting unripe bolls. Improved strain *Cambodia*-3 (Co. 3) came up well in both irrigated and rainfed conditions and fetched a premium in the market. It was estimated to fetch an extra profit of Rs. 25 per acre. A scheme was sanctioned in the year 1942 to multiply the seeds and to help the spread of the strain in Salem district. At the close of the scheme in 1946, an area of 31,000 acres was covered by the pure seeds produced and sold through the department and sales societies. The estimated extra profits realized by the cultivators by way of premium worked out at sixteen lakhs rupees at the end of four years.

(*c*) *The Madras H*-1 *Cotton Seed Distribution Scheme.*—The object of the scheme was to organise the seed multiplication and distribution of Westerns-1 cotton seed over two lakhs acres in the fourth year in three centres at Adoni, Guntakkal and Bellary of the Westerns area. The Agricultural Department was maintaining an area of 3,000 acres for the multiplication of Westerns-1 seed and the seed obtained from it was being utilized for sowing the outer seed farm area under the scheme. For the large scale production, the tract was divided into three units and the seed farms sown in those areas were supervised by the Agricultural Department, rogued, the produce collected and ginned, and the lint sold through co-operative societies. The cleaned seed obtained from the produce was handed over to the societies for sale. The progress of the scheme was not satisfactory due to difficulties in sale of outer seed farm produce. Some modifications were found necessary in the existing marketing conditions and the scheme was prematurely closed in 1946 after running for four years. It is now running as a departmental scheme on an area of 5,000 acres.

(*d*) *The Madras Karunganni Cotton Seed Multiplication Scheme in Ramanathapuram and Tirunelveli districts.*—The object of the scheme was to distribute *Karunganni*-1 seeds to cover an area of 3·5 lakhs acres in the districts of Ramanathapuram, Madurai and Tirunelveli. The inner seed farm was run by the Agricultural Department and the outer area was managed by the Co-operative Societies of Koilpatti, Pudur, Tuticorin, Sattur and Aruppukkottai. The seeds produced by the Agricultural Department were purchased by the co-operative societies for issuing to the seed farm cultivators under their control. The pure seeds

from the outer area were purchased by the societies and sold to the cultivators in the general area. This scheme operated from 1945 to 1947 and was terminated due to the deterioration of *Karunganni*-1 seed. Steps were later taken to multiply the strain *K*-2 from 1948. During 1948–49, 1,300 acres of *K*-2 seed farm were arranged and in the next year 10,000 acres were fixed as the target. However, as a result of the adverse season only 5,800 acres were covered. The work has since been intensified and combined with *Uganda*-1.

(*e*) *The Madras C*11-2 (*K*-5) *Seed Multiplication Scheme.*—The object of the scheme was to extend the cultivation of the improved strain *K*-5 over an area of one lakh acres in the rainfed regions of Coimbatore district. The scheme has been operating from Palladam in Tiruppur area since 1946 and has merged with the combined scheme for *Cambodia*-2 and *Karunganni*-5 since 1949. The ultimate object is to cover 10,000 acres under seed farm and produce about 10,000 bags of pure seeds for distribution in the *Karunganni* zone of the Cambodia tract. This will help in the ultimate unification of the entire *Karunganni* area under one variety capable of spinning 30's warp.

(*f*) *The Madras Combodia*-4 *Cotton Seed Distribution and Marketing Scheme.*—The variety *Cambodia*-4 (*Uganda*-1) cultivated during the summer season in the districts of Ramanathapuram, Tirunelveli, Madurai and South Arcot under irrigation was not pure and the cultivators consequently did not realize the normal premium. A scheme for the multiplication and distribution of *Uganda*-1 seed was initiated in the year 1948 at Srivilliputtur, with the object of ensuring an assured supply of pure seeds to the entire summer area and for extending the cultivation of this strain to cold weather areas also. In the second year of the scheme about 400 acres in the inner seed farm and 4,000 acres for the outer area were covered with a production of about 9,000 bags of pure seed for distribution in 1950–51. The quantity would meet the requirements of the entire *Masipattam* area.

(*g*) *The Madras Cocanadas*-1 *Seed Multiplication and Distribution Scheme.*—A scheme for the multiplication and distribution of *Cocanadas*-1 seeds in Guntur district was sanctioned in the year 1948 with the object of replacing local cotton. The spread of the improved strain will replace inferior qualities and mixed bulks. In the year 1948–49, 184 acres of seed farms were raised and it was ultimately possible to collect harvest from 162 acres only. During the year 1949–50, an area of 1,000 acres was maintained against the projected target of 3,000 acres. It is expected to attain the full target in the next season.

THE COTTON COMMITTEES.

The Indian Central Cotton Committee was constituted in March 1921 on the recommendations of an All-India Cotton Committee presided over by Sir (then Mr.) James Mackenna,

Originally it was purely an advisory body but later, on its incorporation under the Indian Cotton Cess Act in 1923, it became an independent administrative body having at its disposal funds which, with the prior approval of the Government of India, could be spent for promoting research in the interests of the Cotton Industry in India. The chief functions of the Committee are to finance and direct research work on the problems connected with the improvement of Indian Cotton and to advise the Central and Local Government on all matters relating to the maintenance of quality. The work includes in its purview the development of the methods of growing, manufacturing and marketing of Indian Cottons. The members of the Committee include growers, agricultural officers, traders, spinners and manufacturers facilitating mutual co-operation on the many problems affecting cotton and cotton trade. The full committee usually meets twice a year. The funds at the disposal of the Committee are allotted for research on cotton problems including botanical, entomological, mycological and physiological schemes and extension and marketing of improved varieties of cotton in various tracts. Research on cotton technology and comparative spinning tests on new varieties of cotton are conducted at a well equipped Technological Laboratory maintained by the Committee in Bombay. In Madras, the Committee has financed ten breeding, eight seed distribution and two miscellaneous research schemes during the past twenty-six years, involving a total expenditure of 8·5 lakhs of rupees. It has been computed that the growers of the improved varieties earned an additional income of Rs. 89 lakhs in one year (1947–48) as compared with the total expenditure of Rs. 8·5 lakhs incurred by the Committee as subsidies for the various schemes during the past twenty-six years.

The Indian Cotton Committee on whose recommendations the Central Cotton Committee was formed with headquarters at Bombay, proposed further that State and local sub-committees should be formed to work in co-operation with the Central Cotton Committee. A State Committee at Madras and local Committees at Nandyal, Bellary, Guntur, Tuticorin and Tiruppur for the Northerns, Westerns, Cocanadas, Tinnies and Cambodia tracts, respectively, were constituted in 1922. These committees were primarily intended to act as connecting links between the cotton growers on the one hand and the spinners, ginners and exporters of cotton on the other, their most important function being to check, in co-operation with the Central Cotton Committee at Bombay, mal-practices in ginning and pressing. All interests are represented in the different committees and in the State Cotton Committee, the Director of Agriculture and the Cotton Specialist are the Ex-officio President and Secretary. All schemes for cotton improvement work and other matters of special interest like establishment of market committees, policy with regard to price fixation, seed distribution, area extension,

curtailment of area under short staple styles and prevention of mal-practices in trade are considered at the meetings. The Regional Deputy Director of Agriculture is the Ex-officio President of the local Cotton Committees.

LEGISLATION.

The deterioration in the quality of cottons produced in the Madras State was found to be due to the ravages caused by certain insects, the wilful adulteration by the mixing of different grades of cotton and to a limited extent to natural cross pollination. Unlike rice and millets, the cotton grower does not retain his own seed material for sowing purposes as he usually sells his produce as *kapas*. He has, therefore, to depend for his seed material on ginneries and merchants in the bazaar. The local Government realizing his difficulties have enacted various legislative measures in order to minimise the spread of insect pests on cotton, to prevent adulteration with inferior types, to prohibit the cultivation of low grade cottons and to discourage various malpractices in ginning and pressing factories. These have been done in the interests of both the producer and the consuming mills so that the former may get the maximum price for his produce and the latter may be assured of an uniform quality of cotton.

The extension of the provisions of the Madras Agricultural Pests and Diseases Act, 1919, to two insect pests, viz., stem weevil and pink boll worm marks the earliest of such legislative measures. Further Acts for controlling quality by preventing cultivation of low grade cotton, and by regulating markets, transports, ginning and pressing factories mark distinct milestones in the legislative sphere. The objects and main provisions of these enactments as also their defects and utility are briefly summarized below :—

(*a*) *The Madras Agricultural Pests and Diseases Act of* 1919.—This act as amended later applied to two insect pests, *Platyedra gossypiella* and *Pempherulus affinis* attacking *Gossipium hirsutum* under which *Cambodia* and *Pachanadan* varieties are included. The Act required cotton in the notified districts of Coimbatore, Salem, Tiruchirappalli and Madurai districts to be pulled off the ground and allowed to wither before 1st of August. This was enacted on the basic idea of starving the pest through the compulsory removal of *G. hirsutum* in a wide belt of the notified districts. Later modifications, in the operation of the Act, by way of extending the date of pulling by one month, granting exemption to limited pockets of cultivation in the administered area and failure to enforce the Act in certain fields in the notified zones, have defeated the object of the Act.

A review of the operation of the Act by the Government Entomologist, after a lapse of nearly fifteen years of enforcement, revealed that the pest damage to crop remained unchanged. The

recent, intensive research in Madras on the stem weevil has brought out the existence of innumerable host plants which occur everywhere in wild state, the susceptibility of *desi* cotton, which are exempt from the Act and the longevity of the adults, i.e., one month which is longer than the present " no-cotton " interval.

(*b*) *The Cotton Transport Act* (*Act* III *of* 1923).—The object of this Act is to provide for the restriction and control of the transport of cotton in certain well defined zones so that the quality and reputation of cotton grown in such protected areas may be maintained. Under this Act, " cotton " is defined as ginned and unginned cotton, cotton waste, cotton seed, in fact every kind of unmanufactured cotton. The protected areas for cotton in this State are (1) *Northerns and Westerns Area* consisting of the districts of Bellary, Anantapur, Cuddapah and Kurnool (except Markapur and Kumbum taluks), (2) the *Cambodia area* comprising of the districts of Chingleput, South Arcot, Chittoor, North Arcot, Salem, Coimbatore, Tiruchirappalli, Tanjore and that portion of Madurai-Ramanathapuram districts, outside the Tirunelveli area referred to below and (3) *Tirunelveli area*, comprising of Tirunelveli district and portions of Madurai-Ramanathapuram districts lying to the west and south of Kothagudi river, the east and south of Vaigai river and portions of North Vaigai river, bounded by the Periyar channel up to Melur and thence by the Melur-Sivaganga-Manamadura Road.

The Act prohibits the transport of cotton *kapas*, ginned cotton or cotton-waste to a station in any of the protected areas from any station outside the protected area, by road, rail and river. This Act has been helpful to a large measure in checking the mal-practices regarding mixing inferior types with quality cotton and passing off as quality produce by the trade.

(*c*) *The Ginning and Pressing Factories Act* (*Act XXII of* 1925).—This Act has for its objects the better regulation of cotton ginning and pressing factories in the whole of India. This Act requires the owner of every cotton ginning and pressing factory to maintain a register in the prescribed form, showing dates, names of persons for whom ginning or pressing is done, with details regarding quantity ginned or pressed. Further the owner of such factory shall cause every bale pressed in his premises to be marked in the prescribed manner. In addition, weekly returns for each season, commencing from 1st of February of every year are required to be submitted to the Director of Agriculture who consolidates the data for the whole State. The Act further provides for the standardization of weights and measures for cotton transactions in all places. Then it has been useful in regulating the gins and presses and in ensuring greater accuracy in cotton production statistics. It has recently been amended to prevent adulteration of varieties, deliberate watering and mixing seed, leaf and foreign matter.

(*d*) *The Madras Commercial Crops Market Act,* 1933.—The Act, with its later amendments, is to provide for the better regulation of the buying and selling of commercial crops in the Madras State and for that purpose to establish markets for the same. The Act has so far been applied to cotton in the districts of Coimbatore, Bellary, Anantapur and Kurnool. The market committee set up for each of the above places shall consist of not more than twelve members elected from (1) the growers and (2) traders as may be fixed by the Government. The Committee has powers to enact bye-laws, to regulate market prices, including the conduct of proceedings, fixation of tare, commission, trade allowances, standard weights, etc., and the checking of the scales and weights.

(*e*) *The Madras Cotton Control Act* (*Act VII of* 1932).—The Act of 1932 had for its object the prohibition of the cultivation, mixing or to prohibit or restrict the possesion or use of, or trading in the low grade "*pulichai*" cotton (*G. roseum*) either in a pure or mixed form. The Act was enforced in the districts of Madurai, Ramanathapuram, Tirunelveli and Coimbatore. This Act empowered officers of the Agricultural Department to seize *pulichai* cotton from any premises where it was being mixed or grown, and to prosecute the offender by preferring a complaint to the concerned District Magistrates after obtaining the sanction of the Director of Agriculture. As a result of the intensive propaganda and numerous prosecutions launched against offenders in the earlier years, *Pulichai* cotton has almost been eradicated and stray cases only are being reported of late

(*f*) *Restrictions imposed on the cotton cultivation during World War II.*—In order to maximise food production during the pendency of the war, the Madras Government, under the powers vested with them by the Defence of India Rules, restricted the cultivation of short-staple cotton in certain areas of the State. In the Ceded districts of the Madras State, the cultivation of '*Mungari*' cotton except as a mixed crop in the proportion of one line of *mungari* to two lines of food crop was enforced on and from the 15th June 1943. Similarly the cultivation of *Buradapathi* in Visakhapatnam district was prohibited from 1st July 1944, and in its place food crops were ordered to be raised. The cultivation of cocanadas cotton in Guntur district was also prohibited from 1st January 1944 except as a mixed crop in the proportion of 1 : 2 with food crops. In order to compensate for any loss that may be sustained by the cotton grower, a bonus of Rs. 4 for every acre diverted from short-stapled cotton was sanctioned by the Government during 1945–46 and 1946–47. In addition, certain restrictions on raising a crop of groundnut or cotton from any irrigation source—private or public—were also enforced throughout the State of Madras. These enactments jointly contributed to the curtailment of the area under cotton to a considerable extent. These Acts are no longer in force.

(*g*) *Cotton Price Control.*—The India Government in their drive to combat inflation were keen on controlling the soaring price of cloth. It was axiomatic that they should control the price of raw cotton also as a corollary to the price control of cloth. Hence early in 1943–44, floor and ceiling prices were fixed for various types of cotton with specification of staple lengths and allowances due for types 'off' or 'on', the standard. These floor and ceiling prices were ex-godown Bombay with ¼ per cent of brokerage to buyer and included the usual sample and store allowances. The Government announced their intention of purchasing cotton at floor prices in the interest of cotton growers in general. In the event of prices exceeding the ceiling rates named for any or all descriptions, Government retained the right of requisitioning cotton for use by mills. Ever since, floor and ceiling prices have been refixed year after year, for all types of cotton grown in India, after considerable deliberation with all interested parties. An experiment at free trade in cotton for a short spell of about six months in the year 1948 proved to be costly as a result of the sky-rocketing of cloth and cotton prices. Hence, the Government were forced to revert to controls once again. The price structure and control of cotton has been one of the most debated subjects in the country. The Government have recently excluded some of the superior long staple types of cotton like Uganda-1 of the State from the pale of price control, in order to encourage their cultivation to a greater extent. It must be admitted that this control has been helpful in keeping down cloth prices although, the free trade allowed in *kapas* has been a serious loop hole against the full realization of the objective.

(*h*) *The Madras Cotton Trade Census Act.*—The annual census of cotton stocks is at present based on voluntary returns furnished by mills, ginning and pressing factories as also on the statistics supplied by trade associations. In order to provide for the better collection of reliable data relating to the stocks of Indian raw cotton held by the trade in the State, this Act has recently been passed. The Act requires every trader and every owner of cotton as also all ginning and pressing factories to declare the stocks of Indian raw cotton held by them on the 31st January and 31st August of each year. This return has to be submitted to the Director of Agriculture. Heavy penalty by way of fines which may extend up to Rs. 500 has been provided for contravention of the provisions of the Act.

SUMMING UP WITH DISCUSSION ON THE FUTURE.

The cotton improvement work in the Madras State can be reviewed under the four major heads of breeding, agronomy, seed extension and legislation. The first two items falling under the purview of research deal with the betterment of quality and

quantity while the remaining two cover problems incidental to the maintenance of purity of the commodity from the planting to the processing stage. Breeding programmes have received so far greater attention than problems of cotton agronomy and questions of deterioration are being tackled through organized distribution of pedigree seed and legislative enactments. The various Agricultural Research Stations located in the respective cotton zones constitute the permanent centres for carrying out basic experiments on research items.

The erstwhile partition of India and the need to produce more food have very adversely affected the internal raw cotton production of the State. The food compaign has made serious inroads into the prewar cotton acreage, and the supply position of raw cotton has been rendered more difficult in recent times due to dwindling carry over stocks, the expanding mill industry, the mounting spiral of price rise in foreign cottons, the imperative need to conserve both dollar and sterling, and the increasing demand for finer apparel by the consumers. There is therefore an urgent need for drawing up a plan for maximising the raw cotton production of the State without in any manner clashing with the measures undertaken to step up food production. In such a drive, the objects must be to attain self-sufficiency in regard to both quantity and quality of cotton. They require an intensification of research on problems of staple improvement, yield maximisation and reduction in cost of production.

Estimates place the postwar requirements of the State at eight and a half lakh bales of lint per annum—the relative requirements of American and *desi* cottons being roughly equal—for meeting the entire demands of the industry, extra-factory consumption and normal exports. Madras will therefore have to double her annual production, increase the output of quality American by three lakh bales of which 50,000 bales will be Egyptian and to convert all short-staple *desi* into medium quality types. The programme should consist of short and long-term policies. The methods must suit the conditions of peasant farmers who form the bulk of the cotton growers in the State and whose joint contribution even at small levels of increase will ultimately result in a substantial overall production without the need for providing vast sums for capital expenditure and special equipments.

The short-term proposals will consist of investigational work on the possibilities of immediate expansion in non-cotton growing regions and extension work for tested recommendations in the existing cotton tracts. The former will comprise of (*a*) mixed cropping with unirrigated *ragi*, *samai*, *varagu*, rice and gingelly, (*b*) cultivation as border crop in irrigated ragi, groundnut, turmeric and chillies, (*c*) intercropping coconut, arecanut, pepper and fruit gardens, (*d*) utilizing wastelands, backyards and canal bunds for the cultivation of perennial cottons and (*e*) using high level

uncultivated lands in Cauvery-Mettur Project area. The latter in turn will include items like (1) mixed cropping with unirrigated groundnut, chillies, *bajra* and *tenai*, (2) cropping the rice fallows of all districts with short-duration cotton varieties, (3) associated cropping of indigo with *irungu* sorghum and clusterbeans with summer sorghum, (4) early planting of cotton, (5) early removal of sorghum stubbles, (6) adoption of soil conservation methods in arid regions, (7) enlarging the supply of certified seeds and compelling their growths by legislation, (8) planting cotton in lines to facilitate furrow irrigation and intercultivation and (9) extending the use of chemical fertilisers to both irrigated and unirrigated areas.

The long-term plan will comprise of items like (*a*) breeding for high productivity, better ginning and longer staple, (*b*) development of new varieties having short crop life so as to fit in areas having short fallows, (*c*) reduction of crop loss arising out of weather hazards, pests and diseases by breeding, chemicals and agronomy, (*d*) enquiry into the crop husbandry practices for discovering a suitable legume for mixing with preceding cereal crops and (*e*) utilization of select good features of wild cottons for imparting resistance to drought, pests and diseases or for breeding suitable varieties required for special tracts.

STATEMENT 1.—**Estimated acreage and production of cotton in the Indian Union by Provinces and States.*

Provinces and States.	*Area in 000's of acres.*		*Production in 000's of bales of 400 lb. lint.*	
	1936–38. Average.	1947–48.	1936–38 Average.	1947–48.
Assam	39	34	17	14
Bihar	39	39	7	7
Bombay	3,758	2,274 (*a*)	684	410(*b*)
Madhya Pradesh	3,884	2,868	679	557
East Punjab	768	504 (*a*)	295	111(*a*)
Madras	2,320	1,361 (*a*)	455	293(*a*)
Orissa	8	9	1	1
Utter Pradesh	642	155 (*a*)	183	42(*a*)
West Bengal	2	26 (*a*)	1	4(*a*)
Ajmer-Merwara	33	11	12	4
Delhi	2	(*b*)	1	(*b*)
Hyderabad	3,377	1,912	526	277
Baroda	883	423	204	108
Gwalior	647	395	93	79
Mysore	85	46	11	20
Rampur	12	..	2	..
Tripura (Bengal)	32	..	5	..
Bombay States	2,237	..	443	..
Central India States ..	1,292	623	168	109
Punjab States	379	..	181	..
Rajputana States	509	254	88	80
Madras States	24	..	3	..
Total ..	20,972	10,934	4,059	2,116

(*a*) Including States.
(*b*) Below 500 acres.
* Figures adopted from Bombay Cotton Annual 1947–48.

STATEMENT 2.—*The Madras Cotton Crop*—1948–49.

Variety.	*Area in acres.*	*Production in bales of lint (392 lb. nett).* *Staple length denomination.* $\frac{7}{8}''$ and above	*Below* $\frac{7}{8}''$ *and above* 11/16″	11/16″ *and below*	*Total.*
Cambodia irrigated.	162,100	110,500	..	..	110,500
Cambodia unirrigated.	97,200	24,900	..	..	24,900
Tinnevellies unirrigated.	487,900 *	..	115,900	..	115,900
Northerns unirrigated.	28,100	..	9,600	..	9,600
Westerns unirrigated.	648,900	..	60,600	..	60,600
Cocanadas unirrigated.	76,900	..	14,300	..	14,300
Uppam unirrigated.	10,400	..	1,600	..	1,600
Nadam and Bourbon unirrigated.	3,700	..	100	..	100
Mungari unirrigated.	37,000	..	..	3,600	3,600
Chinnapathi unirrigated.	3,600	..	..	400	400
Total ..	1,555,800	135,400	202,100	4,000	341,500

* Includes Karunganni, Uppam and mixed cotton grown in the 'Tinnies' area.

STATEMENT 3.—*Chief distinguishing features of improved American Cottons of Madras State—Cambodia in the South.*

Characters of importance.	*Cambodia*-2.	*Cambodia*-3.	*Uganda*-1 (*Cambodia*-4).
Variety or group	Cambodia	Cambodia	Cambodia.
Habit	Very vigorous, length of stem between successive nodes being long.	Medium vigour—length of stem between successive nodes is short.	Vigorous—length of stem between successive nodes is short.
Crop period	September to March (7 months)	September to February (6 months).	Winter—September to February (6 months). Summer—March to August (6 months).
Branching : Vegetative	One or two well developed strong vegetative branches at the base.	Less of vegetative and more of fruiting branches.	Less of vegetative and more of fruiting branches.
Fruiting	The fruiting nodes are restricted and the early formed flowers generally shed.	Though fruiting nodes are restricted the early formed flowers are not shed.	Fruiting branches are restricted and non-shedding type.
Leaves	Large, dark green with five lobes.	Small, pale green with five lobes	Small dark green with five lobes.
Leaf lobes	Broad and flat	Medium, spoon shaped and margins curving upwards.	Medium, spoon shaped lobes.
Junction of basal lobes	Open	Open	Overlapping at the base.
Flowers : Colour of petal	Cream	Cream	Cream.
Colour of pollen	Do.	Do.	Yellow.
Pigmentation of leaf like structures enveloping the flower and fruit.	Purple colour develops on the veins on sides exposed to sunlight.	Develops only a light wash of purple.	Practically colourless when grown in September to March while in summer light purple colour is developed on the veins exposed to sunlight.
Bolls (Cotton fruits)	Large and tending to droop downwards while on the plant, with 3 to 4 chambers.	Small and tending to point upwards while on the plant, with 4 to 5 chambers.	Small tending to point upwards with 4 to 5 chambers.
Seeds	Big with a dense coating of white short hairs. Egg-shaped and pointed tip.	Medium with a dense coating of light greenish short hairs. Egg-shaped and pointed tip.	Small with a dense coating of greyish green short hairs—Egg-shaped and pointed tip.
Staple : length	21/32″ to 30/32″	30/32″ to 32/32″	30/32″ to 34/32″.
Colour	Dullish white	Bright white	Bright white.

STATEMENT 4-A.—*Chief distinguishing features of improved Desi Cottons of Madras State Karunganni—Tinnies tract in the South.*

Characters of importance.	*Karunganni-1.*	*Karunganni-2.*	*Karunganni-5.*
Variety or group	Karunganni	Karunganni	Karunganni.
Crop period	October to May (8 months)	October to May (8 months)	October to May (8 months).
Locality where grown	As a rainfed crop in the black soils of Coimbatore, Ramanathapuram, Mathurai and Tirunelveli.	As a rainfed crop in the black soils of Mathurai, Ramanathapuram, and Tirunelveli.	As a rainfed crop in both black and red soils of Coimbatore, Tiruchirappalli and parts of Mathurai. Responds to restricted irrigation.
Habit	A short type of medium vigour	A vigorous type	Tall growing and vigorous type.
Branching	Very few vegetative branches	Very few vegetative branches with more of fruiting branches	Two or three strong vegetative branches at the base.
Pigmentation of stem	Lightly pigmented	Purple pigmentation of a deeper shade.	Purple pigmentation develops to a deeper shade as the plants grow older.
Hairiness	Moderately hairy	Sparsely hairy	Sparsely hairy.
Leaves : Size and colour	Medium, green with 5 lobes	Large dark green with 5 lobes	Large, dark green with 5 lobes.
Leaf stalk	Short and green in colour	Very long for the basal leaves and prominently purple in colour on the side exposed to sun-light.	Long and light purple in colour on the side exposed to sun-light.
Leaf lobes	Lobes broad and oblong	Less broad	Less broad and tending to be narrow.
Presence of light greenish yellow gland like structure on the underside of the leaf.	Absent	Prominent nectary present on the underside of leaf.	Prominent nectary present on the underside of the leaf.
Flower	Yellow and with dark purple spot at the base.	Yellow and with dark purple spot at the base.	Yellow and with dark purple spot at the base.
Bracteoles—Leaflike structure covering the flower and boll.	Small and hence not covering the flower or boll completely. With 3 to 5 deeply cut teeth on the margins.	Very large and of a deep purple colour on side exposed to sun. Completely covering the flower and boll with practically no teeth on the margins.	Medium in size and only partly covering the boll—deeply cut margins and lightly pigmented on side exposed to sunlight.
Bolls (cotton fruits)	Small, longer than broad, tapering at the tip with usually 3 chambers.	Large, longer than broad tapering.	Large and broad at the base with prominent shoulders—3 to 4 chambers.
Staple—length and colour	26/32″ to 28/32″—white	28/32″ to 30/32″—white.	28/32″ to 30/32″—dullish white.
Seeds	Small, egg-shaped, tapering with a light coating of white short hairs—greyish in colour.	Small, egg-shaped, tapering and light coating of short hairs—greyish in colour.	Small, egg-shaped and tapering—light coating of short hairs slightly greenish and whitish in colour.

STATEMENT 4-B.—*Chief distinguishing features of improved Desi Cottons of Madras State Westerns, Northerns and Cocanadas Tract.*

Characters of importance.	*Westerns*-1.	*Northerns*-14.	*Cocanadas*-1.
Variety or group	Westerns cotton	Northerns cotton	Red Cocanadas cotton.
Crop period	September to March (7 months).	August to March (8 months)	July-September to February-March (7 months).
Locality where grown	Bellary, Anantapur and Cuddapah districts.	Restricted to Cumbum valley in Kurnool district.	Guntur and Nellore districts.
Habit	A vigorous early type	Medium in vigour and late	Medium in vigour and early type.
Branching	With few vegetative branches and more of fruiting nodes; zig zag in appearance.	More of vegetative branches	....
Hairiness	All parts densely hairy	Very sparsely hairy	Sparsely hairy and purple coloured stems.
Leaves-colour and lobing	Broad in shape, 5 lobes with rounded tips, pale green in colour rumpled in appearance and leathery feel with thick coating of hair.	Broad with 5 oblong lobes. Dark green in colour.	Broad with 5 lobes. Dark green in colour.
Flower-Petal colour	Yellow with a dark purple spot at the base.	Yellow with dark purple spot at the base.	Yellow with a dark purple spot at the base.
Pollen colour	Yellow	Yellow	Cream.
Bracteoles—sheath covering flower and boll.	The sheath covering the flowers tend to grow away from the bolls, i.e., flare away—6 to 8 deeply cut teeth on the margin.	Bracteoles closely envelop the bolls. 3 to 4 teeth in each.	Bracteoles closely envelop the flower stalk, 3 to 4 teeth.
Bolls	Rounded of medium size—Pale green in colour—Smooth surface with no dots.	Tapering and egg-shaped—darker in colour and surface fully dotted.	Egg-shaped, dark green in colour and dotted surface.
Staple—length and colour	26/32″ to 28/32″. Bright white and roughish feel.	28/32″ to 32/32″. Dullish white and silky.	26/32″ to 28/32″. Brownish red and silky feel.
Seeds	Small rounded with thick coating of white short hairs. Egg-shaped with tip.	Small egg-shaped, tapering and lightly coated with short hairs greyish green in colour.	Small egg-shaped, tapering with light brownish short hairs.

CHAPTER 12.

FIBRE CROPS.

Sunnhemp—Jute—Agave—Banana fibre—Other minor fibre crops.

Besides cotton, work on bast and leaf fibres like Sunnhemp, Jute and Agave in addition to a few others of minor importance was done by the Agricultural department.

SUNNHEMP.

(English—Sunnhemp. Tamil—*Sanappu*. Telugu—*Janumu*.)

Sunnhemp is an important leguminous crop grown mostly for green manure in the State but largely used as cattlefeed in the Circars. The soil and climatic requirements of the crop are not very exacting and almost all the districts of the State grow a few hundreds of acres under Sunnhemp for being used either as green manure or cattlefeed. Its cultivation for extraction of fibre is, however, not widespread and is confined to portions of the Circars which grow the maximum area under this crop as might be seen from the figures furnished in the statement below :—

District.	Area in acres in 1948–49.
Visakhapatnam	6,068
East Godavari	14,727
West Godavari	2,401
Krishna	40,800
Guntur	56,012
Bellary	3,728
Nellore	1,176
South Arcot	1,510
Coimbatore	2,222
Total for Madras State	**132,249**

The bast of Sunnhemp yields a fibre stronger than Jute, lighter in colour and more enduring. The fibre is used mostly for the manufacture of cordage, sacks and coarse canvas. The work on this crop was limited to varietal, agronomic and processing aspects and was carried out at the Agricultural Research Station, Samalkota, during the years 1937–42 under a scheme financed by the Indian Council of Agricultural Research. The scheme had for its objects the determination of the most suitable variety for the production of fibre, the best agronomic treatment that would improve yield and quality of fibre, and cheap methods of fibres extraction leading to maximum yields.

The varietal trials consisted of the study of ten Madras types and six other extra State accessions in replicated tests with local *Dummagudam* as control. The observations on growth and yield showed that the early types like Tenkasi, Rasipuram and Samalkota took 2½ to 3 months to mature and their fibre was clean white but possessed bits of pith. The medium duration groups comprising of *Tiruthuraipundi, Dummagudam* and *Cawnpore*-12 came to harvest in 3 to 3½ months and their fibre was the longest and the best. The late types required over 3½ months to mature and the fibre quality was poor. The results conclusively showed that *Cawnpore*-12 was the best type for the Godavari tract from the point of yield and quality of fibre, and crop resistance to insect pests and leaf shedding during untimely rains while the Bellary variety was next in order of superiority. The former registered mean fibre yields of 240 pounds per acre while the latter gave 153 pounds as compared to 105 pounds recorded by local *Dummagudam*.

The agronomic enquiries consisted of sowing dates, seed rate, manurial and harvesting experiments. The time of planting trials with variety *Dummagudam* sown at fortnightly intervals commencing from 1st June and ending with 15th August, conducted for two reasons, were in favour of earlier sowings. No definite conclusions could be drawn from the experiments conducted on three varieties with different seed rates ranging from 30 to 100 pounds per acre for three seasons. The indications, however, were that a seed rate lower than 50 pounds per acre could be adopted without appreciable fall in fibre yields.

The manurial enquiry consisted of tests with two levels of nitrogen, viz., 25 and 50 pounds per acre, in the form of ammonium sulphate, with and without 25 pounds of phosphoric acid in the shape of super-phosphate, on a basal application of five tons of cattle manure. The trials were carried out for two seasons and in the first year all combinations of nitrogen recorded increased yields but the same were not borne out in the next season. It was, however, evident that the addition of super-phosphate did not help in increasing the fibre production. The increase in yield response was not commensurate with the cost of chemical fertilisers applied and as such the practice could not be recommended for adoption.

Experiments to determine the best stage of harvest to obtain maximum fibre yields were conducted for three seasons. The plots were sown on the same day but the harvesting was done at four different stages, viz., preflowering, full bloom, pod formation and seed setting. The results showed that the maximum fibre yields were obtained when the crop was harvested at preflower or full bloom stages, the increase over the other two variants being of the order of 34 per cent.

Processing experiments to evolve profitable methods of extraction of fibre were carried out with variety *Dummagudam*. They

comprised of pretreatment of harvested stalk and study of the effects of variations in the depth of water in the retting pool.

The treatments consisted in retting the stalks after varying periods of drying and the results showed that any period of drying for one month or more consistently lowered fibre yields. The process known as "sweating" the stalks, a practice common in Russia and Italy, was tried but the resultant fibre was poor in quality and dark in colour.

Various depths of water in the retting pool ranging from 6 to 24 inches were tested for retting ten pounds of green stalks. The results were in favour of 9 to 15 inches depth for maximum fibre extraction.

The following useful information was also gathered during these tests: When five pounds of bleaching powder was used for retting the stalks from one acre, the resultant fibre was pure white and suffered no loss in strength. After retting, if the stalks were beaten, combed and cleaned, there was a loss of 25 per cent in yield. Retting was observed to be quicker under still water than under running stream and retting under still, muddy water gave the highest fibre yield and took the shortest time for retting. The length of fibre was also the maximum under such conditions. An increase in the temperature of water used by 10° C had no effect either on fibre quality or colour.

JUTE.

(English—Jute. Tamil—*Sanal*. Telugu—*Janumu*.)

The Jute of commerce is mostly the Bengal Jute (*Corchorus olitorius* and *C. Capsularis*) which is hardly cultivated to any extent in Madras. A few thousands of acres under Bimilipatam jute (*Hibiscus cannabinus*) and mesta (*H. sabdariffa*) are, however, raised in this State mostly in the Visakhapatnam district. The work on these relate to a few varietal tests conducted in the Agricultural Research Stations at Samalkota, Anakapalle, Guntur and Bapatla. The soil and climatic conditions of Bengal are hardly simulated in any part of this State to advocate the cultivation of *Corchorus* as a commercially feasible proposition.

The earliest of trials relate to exploratory tests with *Corchorus capsularis* at the Agricultural Research Station, Samalkota, during the years 1906–1909. It was grown under both dry and wet land conditions. Moderate but not profitable yields were obtained from the rainfed crop. In the wet lands where it was raised in June after a paddy crop, the yields never exceeded thousand pounds of green stalk per acre. The crop was also tried in the uplands of Godavari district in red laterite soils. But the produce was not so good in either quantity or quality of fibre as the Bimilipatam jute. Quality tests of both the samples conducted at the mills were favourably reported upon only for the Bimilipatam jute. The trials were given up as a failure.

Recent trials from 1948 onwards conducted at the Machavaram Farm at Bapatla and Agricultural Reseach Station, Anakapalle, have, however, given encouraging results. Both the species of Bengal jute were tried in the garden lands in the Machavaram Farm during 1948 and the trials were replicated in the subsequent year with the addition of two more varieties, viz., *D.* 154 and *Chinsurah green*. *Corchorus olitorius* gave consistently high yields of quality fibre while early sown *Chinsurah green* was the best yielder with 1,740 pounds fibre per acre.

At Anakapalle, an excellent crop was obtained when grown during July to October under irrigation. But the results of retting operation were vitiated by unprecedented floods during the period. However, the fibre extracted was of good quality yielding 10 to 14 per cent.

Exploratory trials of Bengal jute on ryots' holding during 1949 in three districts, viz., Visakhapatnam, Malabar and South Kanara, were a failure due to adverse season in the first and heavy rainfall in the latter districts.

At the Agricultural Research Station, Guntur, varietal trials with *Hibiscus cannabinus* (Tam. *Pulichai*, Tel. *Gogu*, Kan. *Pundi*) types, local and red gogu from Visakhapatnam and with *sabdariffa* variety from Pusa were conducted as rainfed crop during the years 1932–39. The mean fibre yields were of the order of 233, 311 and 400 pounds per acre respectively for local, *Vizag-red* and Pusa types.

At Anakapalle, *Hibiscus sabdariffa* was raised under rainfed conditions and the stalks were sundried and fibre extracted. The period of retting in this case was observed to be much less than that of jute. Silky and lustrous fibre of good quality was obtained.

AGAVE.

(English—Agave. Tamil—*Kathalai*. Telugu—*Kalabanda*. Kannada—*Kalnaru*.)

The *Agaves* belong to the class of hard fibres and their fleshy leaves serve as the chief source of the world's leading cordage fibre. The numerous species of this genus are only of local occurrence and importance.

The area under *Agave* in this State is negligible and the plants are not cultivated in any field scale. They are generally grown along railway lines and as live fence in garden areas. The fibre is generally extracted by adopting a laborious retting process which hardly gives any incentive to take up the extraction of the same on a commercial scale. In the absence of a cheap hand-operated machine for the extraction of fibre without retting, this industry offers bleak prospects of expansion.

The experimental cultivation of Agave on plantation scale was taken up by the Madras Agricultural department during the years

1901–1908, in the low rainfall tracts of Hindupur taluk of Anantapur district, with the object of studying the performance of different species of *Agave* with particular reference to *Agave sisatana*. The trials were conducted in poor, red gravelly loam with *Agave americana*, *Agave cantala*, *Agave sisalana* and *Furcrea gigantea*. These were planted in well-laid-out plots with seedlings obtained from various parts of South India. All grew well with the exception of *Agave cantala*. When the plants were six months old, the percentage of fibre in *americana*, *sisalana* and *Furcrea* was found to be 1·4, 3, and 3·4 respectively. Fibre extraction tests conducted with *Sisalana* for four years with two or three cuttings of leaves per year yielded a mean of 310 pounds of fibre from an average crop of 900 plants per acre, which worked out at 3·5 per cent of extraction from green leaf to fibre on an average. The samples were valued by the Imperial Institute, South Kensington, at Rs. 450 per ton, which left an inadequate margin as profit. The trials were given up as unfruitful in the absence of an economic method for fibre extraction. The failure of *Agave cantala* which was said to be growing successfully in other parts of India was evidently due to the conditions of low rainfall obtaining in the Ceded districts.

Interest in *Agave* was again revived in 1939 and a fresh consignment of suckers of *cantala* obtained from the Economic Botanist, Bombay, was planted in the Agricultural Research Station at Anakapalle, Pattukkottai, Taliparamba, Samalkota, Guntur, Nandyal, Palur and Aduthurai as also in a few other selected areas in Nellore district. In general the growth was found to be very slow and the suckers made retarded progress during the summer months though irrigations could improve the growth. The possibility of introducing and extending the cultivation of this plant is very limited unless the methods of extraction of fibre are simultaneously improved.

OTHER MINOR FIBRES.

No regular or systematic work worth detailing has been carried out on any of the other fibre yielding plants of minor importance. However, the following observations of sporadic interest may be recorded :—

At the Agricultural Research Station, Pattambi, fibre was hand-extracted from the leaves of Pineapple (*Ananas sativa*) varieties 'Mauritius' and 'Kew'. Though the fibre was fine and well reported upon, the cost of extraction proved prohibitive.

Bowstring hemp fibre extracted from *Sansevieria roxburghiana* grown at Kodur was quite suited for yarn and cordage purposes as reported by the Inspectorate of General Stores, Ordnance Laboratories, Cawnpore.

At Anakapalle, the performance of a crop of *Boehmeria nivea* (Rhea plant) was good, but the extraction of fibre proved to be a difficult task in the absence of standardized methods. The trial

of *Sida-rhombifolia* brought out its unsuitability for fibre purposes as its profuse branching yielded fibre of poor quality.

A survey of the problems confronting the introduction and spread of some of the above fibre yielding plants will clearly show that the primary need is a cheap, effective and standardised extraction process, if a useful cottage industry is to be fostered. When one such method is perfected, the question of discovering suitable types for cultivation in the different regions of the State will have to be taken up most of these types will cater to the every day agricultural needs like plough and mhote ropes, country twine, etc.

BANANA FIBRE.

Preliminary work at Coimbatore in 1943 had indicated that fibre of a few banana varieties might prove a suitable substitute for abaca fibre from *Musa textilis.* At the suggestion of the Director, Indian Army Ordnance Crops, large scale trials on a number of banana varieties were carried out for two years from 1943 at Coimbatore with the aid of a special grant from the Government. The experiments included 1216 pseudo-stems of 72 cultivated varieties, two wild types from Anamalais and Wynaad, and the control *Musa textilis.* The fibre extraction was generally done by the hand method which consisted of stripping the outer portions of leaf stem in the form of ribbons and drawing them under a blunt knife resting on a block of hard wood. The fibre so extracted was dried in partial shade. The summary of results obtained in the trials is given below :—

(1) Among the cultivated varieties, *Kuri Bontha, Pacha Nadan* and *Monthan* proved to be the most promising types for yield of crude fibre.

(2) The strength and quality tests conducted at the Technological Research Laboratories of the Indian Central Jute Committee, Calcutta, indicated the existance of large variations among samples of the same variety. However, the strongest fibre was obtained from *Kari Vazhai, Kai Ethen, Pey Laden, Giant Governor, Kuri Bonthan, Nalla Bontha, Thella Bontha* and *Nana Nendran.* Among them, *Ney Mannan, Nana Nendran,* and *Thella Bontha* combined both strength and quality. It was rather surprising to note that *Musa textilis* as grown in South India secured only a second place both in the matter of quality and tensile strength of fibre.

(3) Appearance of fibre—an important trade requisite—was found to vary with the variety. *Kullan, Monthan,* and *Ela Vazhai* yielded lustrous white fibre, *Nendra Padathi, Booditha montha Bathees* and *Poovan* gave greyish shining white fibre and *Nana Nendran, Nalla Bontha, Krishna Vazhai, Kari Vazhai,* wild banana from Anamalais, *Pacha Montha Bathees* and *Giant Governor* yielded coarse greyish white fibre. The fibre of *Rasthali* variety was silky and shiny, besides being greyish to pure white while that from *Musa textilis* was light ivory yellow and coarse.

(4) The best stage for the extraction of banana fibre was after the harvest of the bunch.

(5) The strongest fibre was obtained from the sheaths of the central folds of the pseudo-stems in some of the varieties.

(6) Banana fibre did not show appreciable deterioration when kept immersed in water and saline solutions for over six months, indicating, thereby its suitability as marine cordage.

(7) Banana fibre was found suitable for rope and gunny making and also for use as graft bandages in fruit nurseries.

(8) The future of banana fibre industry appeared to depend largely on the method of extraction. A simple, cheap and efficient mechanical extractor, if devised, would help the industry.

CHAPTER 13.

FODDERS AND GRASSES.

Production and importance—The Madras Fodder and Grazing Committee—Introduction of useful fodder crops—Grant of concessions —Graminous, Leguminous and miscellaneous fodders—Varietal, cultural and agronomic experiments in the several Research Stations—Trees and shrubs of fodder value—Grasses, indigenous and exotic —Surveys—Nutritive value and palatability—Chemical composition of common fodders and grasses—Yields statement.

Introduction.—The fodders available in Madras are derived mainly from straws of cereal crops grown for grain. Some cereals like sorghum and some leguminous crops like sunnhemp are also exclusively grown for fodder. Besides, stems of plants like groundnut (haulms) and residues from leguminous plants and vegetables are also fed to cattle. Grasses available in grazing areas are known as pastures.

The total cultivated area of this State is about 37 million acres and the natural pastures cover an area of which no accurate estimate can be made and the same remark applies to the grass area in the permanent and reserved forests. The straws of cereals and residues of leguminous crops are seasonal in supply, the grasses of the natural pastures and forests are also seasonal occuring in abundance during the humid months, following the monsoon periods. The supply of fodder is, therefore, plentiful during the humid months and scarce and often unobtainable during the dry months, especially when the monsoon has been a failure. A regular, steady supply of fodder is, therefore, a desideratum. Fodder growing for feeding to livestock is not largely practised in this State as this does not find a place in the usual rotations. This non-inclusion of crops grown for fodder alone is not due to the fact that the cultivator is not aware of the needs of his cattle, but because of the pressure of the population on the land and the pressing need for the production of food crops in adequate quantities as a first charge upon the agricultural economy of the State. The operations of the Agricultural department have demonstrated the possibilities of the successful inclusion of a fodder crop in rotation in places where irrigation facilities are available.

PRODUCTION AND IMPORTANCE.

The Royal Commission on Agriculture (1928) stated " that no substantial improvement in the way of breeding is possible until the cattle can be better fed ". In this State, there are, for every 100 acres of cultivated area, 65 acres of uncultivated land including current fallows. Though this appears large, there is very little

grazing available in these areas. The main grazing available for cattle is furnished by some weed growing on the cultivated land, the grasses on field borders and along water channels, the cultivated plants which spring from seeds falling before harvest and the stubbles of crops. The fodder production in the Madras State for the year 1947–48 is estimated to be derived from the following :—

Fodder from	Area.
	ACS.
Total cereals	21,759,000
Total pulses	2,776,000
Total food crops	26,410,000

The area under food crops in 1947–48 was less than the corresponding area in the previous year by 4·4 per cent.

The Madras Fodder and Grazing Committee published memoirs in 1946 called " A quantitative study of the fodder and grazing resources of the Madras State ". In preparing the memoirs many assumptions have been made. A cow over three years not in milk was taken as the fundamental unit of livestock population unit and termed a cow unit. Relation between this cow unit and other types of animals is given in the table below :—

(1) Working buffaloes and milking buffaloes ..	2	cow units.
(2) Working bulls, milking cows, ordinary buffaloes other than working buffaloes and milking buffaloes.	1½	,,
(3) Other bulls and cows and horses	1	,,
(4) Young buffaloes	¾	,,
(5) Young cattle	½	,,
(6) Sheep and goats	⅕	,,

A satisfactory maintenance ration was assumed to be 6⅔ lb. of dry roughage per cow unit per adult animal of 500 lb. weight. Three pounds of green roughage were taken as equivalent to one pound of dry roughage. The memoir gives the total quantity of available fodder and not fodder and grazing actually utilized.

On the basis of the approximate yields, the State Fodder and Grazing Committee has estimated the total fodder production from cultivated crops and pastures of the Madras State at 32,888,100 tons, as follows :—

	TONS.
Dry roughage	21,645,600
Bhusa of pulses and miscellaneous green fodder ..	3,341,700
Natural grass from pastures	7,900,800
	32,888,100
Concentrated feeds	1,918,000
Total ..	34,806,100

"Taking the bovine stock at 22,644,239, the fodder available per head of cattle works out to 9 lb. per day. A healthy animal weighing on an average 500 lb. requires for maintenance 13 lb. of dry roughages and $\frac{3}{4}$ lb. of concentrates. The fodder produced in this State is, therefore, not sufficient for the feeding of the cattle population."

The supplies of fodder are not uniform all over the State. Depending on the availability of fodder the State Fodder and Grazing Committee divided the whole State into five categories, viz., scarce areas, deficit areas, satisfactory areas, surplus' areas and abundant areas. The scarcity areas are the regions where there is an absolute scarcity of fodder, as for instance, some portions of the Circars and Malabar. The deficit areas are represented by the remaining areas of the Circars, Nellore and portions of North Arcot where there is complete shortage of fodder but the position is not so bad as in scarcity areas. Next are the areas of satisfactory ration where the fodder supply is just sufficient to meet the requirements of the cattle in those regions. These include certain taluks in the Circars and the East Coast and portions of the Mathurai, Tirunelveli, Salem and Coimbatore districts. The surplus areas consist of some taluks in Coimbatore, Mathurai and Nellore. The areas of abundance include some taluks in the Circars, Nellore and Coimbatore. The five regions with their cattle population and fodder production are indicated in the following table :—

Category and description of areas.	Areas in acres. (IN THOUSANDS.)	Human population. (IN THOUSANDS.)	Cow units. (IN THOUSANDS.)	Total fodder and grazing. (IN THOUSAND TONS.)	Total fodder and concentrates. (IN THOUSAND TONS.)
I Scarcity areas ..	15,211	9,124	6,027	3,620	3,752
II Deficit areas ..	26,936	16,613	11,678	9,184	9,599
III Satisfactory ration areas.	22,989	16,147	9,887	11,064	11,385
IV Surplus areas ..	7,523	3,939	3,074	3,485	3,620
V Abundant areas ..	7,839	4,783	2,327	6,399	6,450
Total ..	80,498	50,606	32,993	33,752	34,806

The productivity, ration and population pressure, in the area are indicated in the memoir as follows :—

Category.	Actual figures. Productivity.	Ration.	Pressure.	As percentage of standard or average. Productivity.	Ration.	Pressure.
I ..	1·05	2·76	682	52	56	100
II ..	1·64	3·76	746	81	77	109
III ..	2·28	5·19	790	112	106	116
IV ..	2·34	6·66	612	115	135	90
V ..	4·20	11·27	678	207	230	99
Standard or Average.	2·03 lb. per acre per day.	4·91 lb. per day.	728 units per 1,000 acres.			

According to the Fodder and Grazing Committee estimates, the total amount of dry roughage equivalent, which has to be imported from surplus areas or produce in deficit areas in addition to present production, amounts to nearly 12,100,000 tons of dry roughage, equivalent or about 36,300,000 tons of green roughage. As fodder is a bulky commodity, which is extremely expensive to transport by rail and cannot be transported by water to the areas where the deficits are found, the greater part of this total, the equivalent of 12,000,000 tons of dry roughage or 36,000,000 tons of green roughage has to be produced in the regions falling in categories I, II, III if the cattle in those regions are to be given satisfactory daily ration. The Fodder and Grazing Atlas of the Madras State is of use in the study of the fodder problem of the Madras State.

The problem of increasing fodder production is now being tackled in two ways, firstly, by the introduction of several useful fodder crops and secondly by the grant of concessions to encourage the extended cultivation of fodder. Due to Government concessions, there was an increase in the area under fodder crops as shown below :—

Year.	ACS	Year.	ACS.
1910–11	264,371	1940–41	459,455
1920–21	298,872	1944–45	459,653
1930–31	449,865		

If under the future planning of agriculture, the productive land is increased, it will necessarily result in an increased yield of foodgrains per acre. Increase in grain yield will naturally result in an increase of the straw yield. The fodder problem of the cattle is thus correlated to the food problem of the human population.

The table below gives the areas cropped and the trend of cropping (in 1,000 acres units) :—

Year.	Net area sown.	Current fallow.	Area under non-food crops	Area under fodder crops.	Other uncultivated land other than current fallows.
1902–03	25,740	5,203	..	189	5,979
1903–04	25,689	5,694	..	228	5,623
1904–05	24,151	7,235	..	238	5,863
1925–26	33,834	10,144	8,754	388	12,352
1926–27	33,263	10,874	8,103	455	13,218
1927–28	33,793	10,087	8,697	423	13,271
1944–45	31,534	9,290	9,031	460	11,434
1945–46	30,584	9,779	8,849	463	11,952
1946–47	31,035	9,498	8,785	563	11,849
1947–48	30,078	10,037	8,223	394*	12,187
1948–49	30,934	10,048	8,278	443	11,390

* Due to bad monsoons.

In the year 1948–49 out of 52·30 million acres of total cultivable land of the State, about 11·4 million acres were uncultivated lands

out of the remaining lands, the net area sown was 30·9 million acres while the current fallows accounted for 10·05 million acres. These current fallow lands which were only 5·2 million acres in 1902–03 very rapidly increased to 8·2 million acres in 1907–08 and reached 10·1 million acres in 1925–26. From that time the current fallows varied from nine to ten million acres. Cultivation of these marginal lands means so much utilisation of extra animal power for obtaining what at best will be marginal yields in years when seasonal conditions are favourable. In years of drought these current fallows hardly contribute any grass fodder, even for the cattle which plough them. In our State more than 93 per cent of cattle depend on agricultural land for their fodder and only some 7 per cent resort to forest grazing. Crop residues such as straws of cereal crops, haulms and bhusa of pulse crops, etc., form the chief sources of fodder. The position at present is such that even if an increase of 50 per cent is secured in straw yields by adopting intensive methods of cultivation, we are still faced with a huge deficit of 20 million tons of dry roughage per year.

CLIMATE, SOIL, IRRIGATION, ETC., WITH THEIR INFLUENCES ON CROP PERFORMANCE AND CULTIVATION PRACTICES.

Fodder crops are not raised generally under irrigation. *Pillipesara* (*Phaseolus trilobus*) is gaining popularity as a fodder *cum* green manure crop. This is raised after rice to a large extent in Godavari and Krishna deltas and also to a limited extent in the South. *Pillipesara* is given an irrigation or two, if raised in wet lands and cuttings used for fodder, the last one being used as a green manure. Sunnhemp is another crop raised specially for fodder after rice in wet lands in large areas in Krishna and Godavari Deltas. In this case, the sunnhemp is not irrigated. Permanent fodders like Guinea and Napier grasses are raised only in few sewage farms near big towns and Government Farms, where they occupy the lands for some years. In such cases no definite rotation is adopted.

Pastures are not irrigated in this state and no forage mixture is raised under irrigation.

VARIETAL INTRODUCTION AND TRIALS.

The fodders that were studied in the various agricultural stations can be classified as I gramineous, II leguminous and III miscellaneous. The crops coming under each group are detailed below :—

I. *Gramineous fodders*—

(1) Rice.
(2) Sorghum.
(3) Bajra.
(4) Ragi.
(5) Samai.
(6) Maize.
(7) Teosinte.

II. *Leguminous fodders*—
(1) Pillipesara.
(2) Sunnhemp.
(3) Cowpea.
(4) Horsegram.
(5) Lucerne.
(6) Berseem.
(7) Other pulses.

III. *Miscellaneous fodders*—
(1) Sunflower.
(2) Sweet potato vines.
(3) *Kollaganjeru* (*Ipomea hispida*).
(4) Subterranean clover.
(5) Trees and shrubs of fodder value.
(6) Weeds of fodder value.

I. *Garmineous fodders—Cereals*.—The straws of cereals form the major fodder.

(1) *Rice* (Oryza sativa).—Rice is raised over an area of about 11 million acres and an average acre yield of 2,500 lb. of straw is obtained. This stands storage and is the main fodder in the deltaic areas.

(2) *Sorghum* (Sorghum vulgare) (Tamil—Cholam; Telugu Jonna; Hindustani—Jowar).—This crop is eminently suited to be the mainstay of fodder in regions of low to moderate rainfall and occupies an area of about four million acres in Madras State. It needs less water per pound of dry matter than perhaps any other cereal crop, " its average water requirement being 294 lb. per pound of dry matter as against 309 for maize, 388 for Sudan grass, 375 for Teosinte, 470 for wheat and 600 to 900 for leguminous fodders like lucerne and cowpea ". It does not suit tracts having long periods of heavy rainfall.

About 91 per cent of sorghum is rainfed. The yields of sorghum in the different Research Stations of the Madras State are given in the following table :—

Agricultural Research Stations.	As straw from grain crops per acre.		As a pure fodder crop per acre.		Variety found most suitable.
	Rainfed.	Irrigated.	Rainfed.	Irrigated.	
	LB.	LB.	LB.	LB. (green weight).	
Anakapalli ..	..	..	..	14,970	..
Guntur ..	..	..	3,500	..	N/23/10
Chintaladevi ..	..	..	3,400	..	Pedda Jonna.
Hagari ..	2,000	..	..	18,450	
Nandyal ..	..	..	3,590	..	N. 29/82.
Palur	..	..	..	14,820	Kaki Jonna.
Tindivanam ..	..	..	5,430	21,830	Peria Manjal.
Aduthurai ..	..	..	..	14,530	
Pattukkottai ..	..	..	..	15,930	
Coimbatore ..	3,150	6,460*	..	23,900	Peria Manjal.
Hosur ..	3,150	..	..	19,120	Do.
Gudiyattam ..	..	..	..	20,750	Peria Manjal.

* Chitrai cholam.

Agricultural Research Stations.	As straw from grain crops per acre.		As a pure fodder crop, per acre.		Variety found most suitable.
	Rainfed.	Irrigated.	Rainfed.	Irrigated.	
	LB.	LB.	LB.	LB.	
Taliparamba ..	..	..	..	10,410	Do.
Pattambi ..	..	..	4,750	..	Do.
Koilpatti ..	..	5,500	3,540	19,100	Irungu.
Nanjanad ..	..	..	Failure.	..	..

At Anakapalle, sorghum for fodder could be grown as a rainfed crop in June giving an outturn of 9,000 lb. per acre as well as under irrigation after the harvest of summer ragi in April, the yields ranging from 10,000 to 25,000 lb. per acre. In the Guntur station, the average yield from rainfed sorghum was 3,500 lb. of dry fodder per acre the best variety being Nandyal N. 23/10. Periamanjal cholam grew well but was inferior in hay quality. To improve the feeding value of the fodder, it was found best to grow sorghum mixed with *Pillipesara* (*Phaseolus trilobus*) in the ratio of 3: 1. Higher proportions of the legume decrease the yield. From the June-sown rainfed crop, Chintaladevi farm (1918–1932) recorded an average yield of 3,400 lb. of dry fodder. Manuring was found uneconomical.

In the Ceded districts the average yield of straw was 3,600 lb. at Nandyal, 2,000 lb. at Hagari, while under irrigated conditions at Hagari, the outturn went up to 18,450 lb. At Nandyal the local spacing of 10½ inches between rows was found to be the best, while at Hagari the existing local practice of 18 inches spacing between rows was more profitable. Closer spacings increased the outturn of straw. Application of *poudrette*, ammonium sulphate and super phosphate was beneficial in favourable years.

At Palur farm (South Arcot) *Periamanjal* cholam has not done well, the two suitable types being *Kaki Jonna* of Madanapalli and *Sencholam* of Polur. At Tindivanam, *Periamanjal* gave an average yield of 5,430 lb. under rainfed conditions and 21,830 lb. under irrigation. At Aduthurai representing the Cauvery Delta, *Periamanjal cholam*. sown in *Samba* rice fields in June and harvested by September, gave an outturn of 14,500 lb. of green fodder

At Coimbatore, *periamanjal* sorghum was the dominant variety with an average yield of 3,150 lb. of straw from the rainfed crop and 23,960 lb. as irrigated green fodder. Sorghum is grown in a variety of soils, black soil dry lands, red soil dry lands, red soil garden lands and even in heavy soils of the wet lands. At the Central Farm, sorghum recorded poor yields for periamanjal between August and January than when raised from February and July, as the crop rushed to flower from September to January. Hence at Coimbatore fodder maize is preferable throughout the year and sorghum from February to July. Fodder crops are best cut soon after they flower; sorghum contains a cynogenetic glucoside in the early stages, more so in a ratoon crop. The quantity of fodder consumed per pound of milk produced was in the descending order, viz., guinea grass, fodder sorghum and fodder maize.

At Hosur Cattle Farm, the average fodder yield was 3,150 lb. for the rainfed and 19,120 lb. for the irrigated sorghum. In the West Coast Research Stations, the yield varied from 4,000 lb. to 10,400 lb. of green fodder per acre. *Irungu. cholam* (*Sorghum dochna* (Forsk) *var. Irungu* (Burkill, snowden) was shorter in duration, more drought resistant and less susceptible to earhead bugs and sugary disease than *perianianjal cholam*. At Koilpatti Farm it was found that cutting the crop at the shot blade stage gave definitely better quality of fodder with less outturn and the yield of the subsequent cotton was not so adversely affected as when sorghum was cut after setting seed. The average yield for a rainfed irungu crop in the black soils was 3,540 lb. of dry fodder per acre and on red soils under irrigation 5,500 lb. of dry straw from a grain crop. Early trials with "fish guano" and "Nitrolim" increased yields from 46 to 60 per cent but later experiments of 1930-34 showed that manuring with fertilizers like Ammonium Sulphate and Superphosphate was not economic.

Trials with exotic sorghums.—In 1915-16 a variety from Belgian Congo was tried under irrigated conditions and in 1932, "*Billichigam sorghum*", a Bombay type was grown on black soils; these types were given up, as in the former seeds setting was poor while in the latter "*Calocoris*" bug attack was phenomenal.

In the Nilgiris district, sorghum failed at Nanjanad while at the Imperial Dairy Farm, Wellington, yields from 10,000 to 15,000 lb. of green fodder per acre were recorded.

Exotic types like "*Chinese sugarcane*" and "*planker friend*" (at Saidapet), American types such as "*Red Kafir*" and "*Dwarf milo*" at the Central Farm, Coimbatore, and "S. Margarestiferem" at Taliparamba were tried, but with no success.

(3) *Bajra* (Pennisetum typhoides Stapf and Hubb.) (Tamil *Cumbu*; Telugu—*Sajja or Ganti*; Hindi—*Bajra*).—In 1879 it was observed at Saidapet that bajra grew very well under irrigation yielding 15,000 lb. within a period of about 75 days although it was not quite equal to sorghum either in quantity or quality. The green crop was suited for making silage. At Hagari the average yield of an irrigated crop was 11,300 lb. while at Palur the yield was 7,600 lb. under rainfed conditions raised from July to September. The yields of bajra in the different stations in the Madras State are given in the folowing table :—

Average yield of fodder bajra in pounds per acre.

Agricultural Research Stations.	Pure fodder crop Irrigated. LB.	Remarks.
Chintaladevi	2,300	Low fertility of soil.
Coimbatore	31,000	In 33 days.
Taliparamba	13,500	Pennisetum lenois from Sierra Leone tried in 1933 in wetlands.
Pattambi	9,100	Local type.
Koilpatti	16,300	Local, in red lands.

At Koilpatti a variety from Belgian Congo was found good in 1916 as an irrigated fodder crop in red soils.

(4) *Ragi* (Eleusine coracana, Gaertn), (Tamil)—*Ragi*; Telugu—*Ragi*).—This crop has not been tried anywhere as a fodder producer. The straw improves on ensilage.

(5) *Samai* (Pancium miliare, Lamb).—This minor millet has great potentialities as a quick growing fodder. At Saidapet, it was reported to have yielded 47,000 lb. per acre under irrigation in two cuttings within 138 days. At Aduthurai (1933–36) Samai gave 13,200 lb. as green fodder within a period of 55 days. It failed at Pattambi but was successful at Nanjanad (Nilgiris district) both as a grain crop and as a green fodder crop.

(6) *Maize* (Zea mays) (Tamil—*Mukkacholam*; Telugu—*Mokka Jonnalu*; Kannada—*Muskinjola*; Hindi—*Butta*; Malayalam—*Makka cholam*).—This crop is superior to sorghum on account of its quicker growth, non-poisonous nature and uniformity of yield all through the year but is less hardy and less adaptable to soil and climate variations than sorghum. The maize crop gives huge quantities of green fodder which can be used in the form of silage. At Guntur it was grown both as an early and as a late season crop, and the yields ranged from 1,640 lb. to 4,100 lb. per acre under rainfed conditions. The yields of maize in the different stations in the Madras State are given in the following table :—

Average yield of fodder maize in lb. per acre (Green weight).

Agricultural Research Stations.	As pure fodder crop. Rainfed.	Irrigated.	Remarks.
Saidapet	..	12,000–17,000	....
Hagari	..	4,350–11,600	Cultivated since 1931.
Nandyal	2,200	..	Tried in 1930 only.
Chintaladevi	4,000	..	(1921–32) average.
Hosur	..	13,300	(Just when cobs formed increases milk yield of cows).
Kasargod	3,500	..	Inter crop in coconut plots.
Pattambi	2,000	..	In *Modan* lands.
Koilpatti	..	3,000– 3,800	(Highest yield 30,800 lb. in 1936 with *poudrette*).

(7) *Teosinte* (*Euchlaena mexicana*).—This maize ancestor introduced at Saidapet in 1881, was found a heavy yielder but could not withstand drought and was, therefore, limited to moist tracts or where irrigation was possible. The fodder was, moreover, very watery and devoid of any sugary matter and not quite palatable for stock feeding. Contrary to the above, it was very well relished by stock at Hosur being distinctly sweet at the flowering stage and like maize capable of stimulating milk production when cut and fed at the optimum stage. The yields of

teosinte at the different stations in the Madras State are given in the following table :—

Average yield of green fodder teosinte in pounds per acre.

Agricultural Research Stations.	As pure fodder crop. Rainfed.	As pure fodder crop. Irrigated	Remarks.
Guntur	4,000	..	Early season.
	2,900		Late season (Pairu).
Palur	..	34,800	Sown in July—Harvest two weeks earlier than cholam.
		3,600	October sown.
Aduthurai	..	4,100	....
Coimbatore	..	28,400	....
Hosur	..	25,000	....
Taliparamba	930	20,800	....
Pattambi	Failure.	Failure.	....
Koilpatti	1,500	10,200	....
Hill stations	..	19,500	....

II. *Leguminous Fodders*—(1) *Pillipesara* (Phaseolus Trilobus).—This is the most popular fodder and green manure legume grown in the deltas of Krishna and Godavari, now also extending to other parts of the Madras State. The plant is wiry and crawling stands two to three cuttings for fodder and then gives a fair outturn of seed and is less susceptible to insect pests than sunnhemp. The yields of *Pillipesara* in the different stations of the Madras State are given in the following table :—

Average yield of Pillipesara fodder in pounds per acre.

Agricultural Research Stations.	As pure fodder crop. Rainfed.	As pure fodder crop. Irrigated.	Remarks.
Samalkot	..	15,600	Sowing in November in the standing crop of rice found best in 1929.
Maruteru	..	..	Ryots grow on field bunds in monthly sowings from June for fodder.
Guntur	10,700	..	Punasa (July to September) 3 : 1 *Sorghum Pillipesara* found good.
Nandyal	11,200	..	3 : 1 Sorghum—Pillipesara mixture pulled down grain yield.
Hagari	..	6,700	....
Chintaladevi	2,200	..	....
Aduthurai	..	16,000	(i) April sown irrigated crop—two cuttings taken by November and left for seed. (ii) sowing in rice in November good—after one cutting, ploughed as green manure. (iii) Mixed crop from June to September with maize fit for fodder and silage.
Coimbatore	..	11,000	Wet lands.
Hosur	6,800	..	Grown from 1929.
Koilpatti	3,203	18,500	Grown from 1931.

Pillipesara as hay.—During 1939, *pillipesara* dried and pressed into bales of 80 lb. at Aduthurai, was fed to cattle at Coimbatore in feeding trials. Each group consisted of three individuals; one received only *pillipesara* hay, one only rice straw, and the third a mixture of both the fodders in equal proportion. It was found that good *pillipesara* hay is equal in palatability to good rice straw.

(2) *Sunnhemp* (Crotalaria juncea)—(Telugu—Janumu).—The sunnhemp Gopalpore is a dual purpose legume fit for both fodder and green manure. It is fed green dried like hay (as in Krishna district) or is grazed in the field. It grows well on a wide variety of soils but is susceptible to insects. The sowing in November in the standing rice did not always give a good crop, as the damage from caterpillars was very much more severe than when grown in March under irrigation. The yields of sunnhemp in the different stations in the Madras State are given in the following table :—

Average yield of sunnhemp fodder in pounds per acre.

Agricultural Research Stations.	Fodder. Dry lands.	Fodder. Wet lands.	Remarks.
Samalkot	..	14,300	....
Maruteru	..	15,700	....
Guntur	2,000 (dry fodder)	..	Sown in July or August—optimum time second week of August.
Hagari	..	6,000	(green) Silage prepared from July sown crop.
Nandyal	failed.	26,000 (irrigated)	in 1925.
Chintaladevi	1,900	..	Hay—July sowings better than September or December sowings.
Palur	..	5,100	Green manure.
Palakuppam	..	3,400	Hay.
Aduthurai	..	16,300	Green manure—June sown.
		1,900	December sown crop—pest attacked.
Hosur	..	8,600	For silage.
Pattambi	4,700	10,000	Not suited—sown in September in 1932.
Koilpatti	..	8,700	Irrigated red soils—crop for silage making.

It was found that by sowing sunnhemp in September on field bunds and taking care to nip off the top shoots just before the floral shoots appeared, buds were induced to form in greater profusion on the axils of leaves and a good seed crop was obtained without difficulty. The cost in this case worked out only to a

rupee per 160 lb. of seed as against Rs. 30 to 50 often charged by middlemen.

(3) *Cowpea* (*Vigna catjang, Walp*).—Among the leguminous fodders, cowpea appears better suited to the humid West Coast than anywhere else. Its performance in the different stations is given below :—

Average yield of cowpea fodder in lb. per acre.

Agricultural Research Stations.	Weight of fodder in lb.	Remarks.
Chintaladevi	1,500	Sown in Punasa.
Samalkot	..	Better sown in November in rice standing crop than as irrigated crop in February.
Maruteru	..	Sown on bunds with *pillipesara* and sunnhemp from June onwards.
Guntur	..	Grown in 1933–36 for green manure.
Hosur	6,600	....
Palur	6,400	For green manure.
Aduthurai	10,700	For green manure.
Coimbatore	..	Not prominent for fodder or green manure.
Koilpatti	14,500	Under irrigation, failed.
West Coast	..	May end to June, early sowings best.

(4) *Horsegram* (Dolichos biflorus)—(Tamil—*Kollu*, Telugu—*Ulavalu*, Malayalam—*Muthira*, Kannada—*Huruli*, Hindi—*Kulthi*).—Horsegram is the most extensively grown pulse crop, corresponding in this respect to the Bengalgram crop of Northern India. Horsegram furnishes concentrated feed for cattle supplementing the bulky straw fodders. Invariably it is grown as a dry crop under a moderate rainfall not exceeding 35 inches. In tracts of higher rainfall, it is sown after the rains have ceased, growth being due to the soil moisture helped by the dew of the season. It is grown over a wide range of soils, excepting the badly alkaline soils; it is a kind of preparatory crop on the new land. Benson from Saidapet (1879) reported that it is capable of yielding as much as 10,600 lb. within about 70 days, under moderate application of manure to the rainfed crop. It makes excellent hay with very palatable smell, the dry weight being about 25 per cent of the green weight.

At Anakapalli horsegram is broadcast in the *Pedapanta* season (August to September) and in *Punasa* season (June to July) after *ragi or ganti* (bajra). At Samalkota and Maruteru it is sown in the standing rice crop in November, and pods gathered in

February. The *bhusa* (residue of vines and empty pods) is used as cattle feed. In the uplands it is broadcast in October after an early crop of gingelly or cereal and harvested in February. The yields of horsegram fodder in the different stations are given below :—

Average yield of horsegram green fodder in pounds per acre.

Agricultural Research Stations.	Yield of fodder.		Remarks.
	Rainfed.	Irrigated.	
Hagari ..	4,800	8,100	Not popular in the black-soil of Ceded Districts.
Chintaladevi	900	..	November sown after sorghum and bajra pure or mixed.
Palakuppam	5,600	..	In 1931 after bajra.
Coimbatore	3,900	..	....
Hosur ..	2,000	..	Horsegram, lab-lab and gingelly grown on large scale in Hosur tracts.
Taliparamba	..	..	Mainly as a grain crop after *modan* rice mixed with *samai* (panicum miliare) gingelly or sweet potato.
Pattambi ..	3,050	..	....
Kovilpatti ..	..	12,700	In 1936 in red soils.

(5) *Lucerne* (Medicago sativa).—This valuable fodder crop was first introduced in Madras in 1916 in the Central Farm, Coimbatore, and is since being regularly kept on successfully. Though its value as a nutritious fodder is recognized, it is confined only to small plots in private farms of progressive ryots of the State, besides Government farms. This crop is thriving well in the hot climate of this State though a native of temperate Asia originally. The cuttings are heavier in the cold months from November to January than in the hot period of May to July. The crop needs a deep well drained loam rich in lime with adequate manuring and irrigation. Sullage water can be used with advantage. Being a rich feed it would suffice to give five to ten pounds per animal per day and on this account only small plots are raised in the farms. It did not thrive well in the West Coast due probably to the very heavy rains and the shallow lime-deficient laterite soils of the area. The average annual yield was 36,000 lb. per acre in six to ten cuttings. The crop is raised from seed and is usually kept three to five years.

Apart from its value as forage crop, lucerne is also reported as useful in the control of malaria in countries like Egypt, Argentina and Caucasus region. The cost of cultivation was rather high in the beginning at Coimbatore, namely 149 lb. per rupee in 1917 or Rs. 122 per acre, and the average was 425 lb. per rupee. Attempts to introduce this crop in the Sircars have not been very

successful. The performance of lucerne in the various Agricultural Research Stations is noted below :—

Agricultural Research Stations.	Average yield in lb.	Remarks.
Samalkot	25,000	In 1931, given up subsequently.
Guntur	650	....
Chintaladevi	1,040	Maximum yield.
Hagari	..	Grown in 1918, 1919 and then continued from 1922 every year.
Palur	..	Grown in three cents.
Tindivanam	14,100	....
Hosur	30,220	From 1924.
Taliparamba (West Coast) ..	..	Failed due to heavy rainfall coupled with shallow laterite lime deficient soils.
Koilpatti	27,300	In six cuttings.
Nanjanad (Nilgiris) ..	27,400	....

(6) *Berseem* (Trifolium alexandrinum, Linn).—Berseem is a highly nutritious and succulent fodder for dairy cattle. It is a quick growing annual leguminous plant of succulent hollow stems, abundant leaves and rapidly decomposing roots full of bacterial nodules. It, therefore, lends itself to be a very useful rotational crop even on highly priced lands without reducing fertility. It is very doubtful if there is any other annual forage crop in the world which can be cut four or five times in a season producing as much as four to seven tons per acre, at each cutting Being an annual grown for centuries under copious irrigation, it has a very shallow root-system. It is, therefore, not suitable for cultivation on dry arid soils even where the deeper layers are moist. This crop was tried at the Central Farm in 1924 and at various other centres, namely, Hosur 1928, Samalkot 1929, Anakapalle 1933 and Koilpatti 1935, but was found poor in outturn. Finding that berseem was a failure in 1938–39 when it was sown in the normal sowing seasons of the State, an attempt was made in 1939–40 to obtain berseem seed from Peshawar which was tried at most of the Agricultural Research Stations. To ensure good growth, the seeds were treated before sowing with a culture of berseem nodule organism supplied by the Government Agricultural Chemist. Optimum conditions of soil, manuring and irrigation were given in all trials. In most of the places, the seeds germinated well, but the subsequent growth was not uniform. The trials indicated that the months of September (Hagari), October (Siruguppa and cotton Breeding Station, Coimbatore) and November (Anakapalle and Tindivanam) were favourable for the growth of berseem. When sown out of these months the crop either failed or was stunted and gave very poor yield. Berseem was a total failure at Samalkot, Guntur, Kalahasti, Nandyal and certain villages in the Tanjore district, Taliparamba and the coconut stations in South Kanara. Poor yields of 1,000 to 5,000 lb. of green fodder per acre were recorded at the Botanic Gardens,

Ootacamund, the Central Farm and the Millet Breeding Station at Coimbatore. At Anakapalle, Hagari, Siruguppa, Koilpatti and the Cotton Breeding Station, Coimbatore, berseem gave fairly heavy yields varying from 10,000 to 20,000 lb. per acre, but in all places the crop was unable to survive the hot weather (commencing in March) and dried up after two or three cuttings.

From the trials made so far, it is seen that (a) berseem seed germinates well and comes up better if grown before winter, (b) that it requires heavy manuring, copious irrigation, retentive soil and temperature below 90°F, (c) that if any of the above conditions are not satisfied, the crop gives less yield, (d) that above all it has a very poor seed setting habit in this State, which is a serious drawback and (e) that the crop cannot therefore be recommended to ryots except in elevated places like Hosur, Kotagiri, etc.

Considering the fact that this crop fails to set seed, and the fact that seed for sowing an acre costs Rs. 7 to Rs. 8 when imported from outside, berseem has not much scope as a fodder legume in this State.

(7) *Other pulses.*—(i) Blackgram (*Phaseolus mungo* L). Kannada—Uddu; Tamil—Ulundu; Telugu—Minumulu or Uddulu; Malayalam—Uhunnu; Hindi—Udid.

(ii) Greengram (*Phaseolus aureus* Rox). Kannada—Hisaru, Tamil—Pachai payeru, Telugu—Pachpesalu, Malayalam—Cherupayeru, Hindi—Mung.

(iii) Bengalgram (*Cicer arietinum* L). Kannada—Kadale; Tamil—Kadalai; Telugu—Sanagalu; Malayalam—Kadalakka, Hindi—Cheenai.

(iv) Theegapesara (*Phaseolus sublobatus* Roxb).

(v) Lab-lab (*Dolichos lab-lab* L). Kannada—Avare; Tamil—Mochai; Telugu—Anumulu; Malayalam—Mochakotta; Hindi—Ballar.

(vi) Lentils (*Lens esculenta*, Moench).

(vii) Lupins—(*Lupinus* spp).

(viii) Soyabeans (*Glycine max merryl*, *G. Soya*).

(ix) *Glycine javanica*, L., a legume which was collected in lower ranges of Coimbatore has proved to be a well spreading legume in addition to its possessing good feeding value. It is drought resistent and is easily raised from seeds.

(x) *Alysicarpus rugosus*, DC. was successfully tried as a mixture in the grass lands in Bhavani reserve forests of Coimbatore district.

The first five are grown as catch crops on all types of lands, specially the poorer types of soils; the grain is used as food while the *bhusa* is fed to cattle. At Samalkota blackgram or greengram or theegapesara (creeping greengram) and sunnhemp are sown

broadcast in the standing rice crop in November. After the harvest of rice, the pulses remain in the field till February when the pods are gathered and the sunnhemp is cut for hay or grazed down. The performance of the minor pulses at the various Research Stations is given in the following table :—

Performance of minor pulses as fodder (in pound per acre).

Agricultural Research Station.	Black gram.	Bengal gram.	Green gram.	Theegapesara.	Lab lab.	Soybeans.	Lupins and Lentil.
Samalkot	..	..	....	14,500 March sown. Irrigated.	..	Behrum pengypi promising.	..
Maruteru	..	..	Periodical cuttings for fodder—sown in July on wet land bunds.	....	..	..	..
Chintaladevi.—All legumes grown as mixtures with *pedda jonna* and *pairu jonna*.							
Palur.—Blackgram and bengalgram tried as second crop after bajra, not promising							
Coimbatore.—*Bhusa* fed to cattle—green fodder.							
Hosur	..	..	....	....	..	..	5,400 (1936)
Koilpatti	11,500	..	....	....	..	..	..

III. *Miscellaneous fodders*—(1) *Sweet potato.* (Ipomoea batatas, *Poir*).—The vines stimulate milk secretion when fed to cows and constitute a palatable green feed. At Chintaladevi the average outturn was 8,000 lb. of vines per acre (1921–24). At Hosur the average yield was 29,000 lb. vines and 6,409 lb. tubers. At Coimbatore in 1929, 1933 and 1936 it was grown and fed to cattle. For the last two or three years sweet potato as a subsidiary food crop has gained great importance and several American and other exotic varieties are under trial in the various research stations of the State.

(2) *Sunflower* (Helianthus annus, Linn).—Sunflower makes a palatable silage; it is a quick growing, heavy yielding crop, not much relished at first by cattle. At Chintaladevi it yielded 10,000 lb., at Hosur 31,700 lb., and in the Central Farm 7,000 lb. (1924). Sunflower was tried in various centres in the Madras State. It was a failure on the hills and in the West Coast.

(3) *Kollaganjeru* (Ipomoea hispida R & S).—This is a hardy, creeping drought resistant annual of high feeding value, being rich in proteins, fats and potash; it stimulates milk yield. It was a success in Coimbatore (28,000 lb. of fodder) Guntur, Bellary and Pattambi (7960 lb. of fodder) and was also found to be effective in smothering weeds.

The results of the trial of *Ipomoea hispida* R & S. as a fodder crop on the Agricultural Research Stations at Aduthurai, Palur and Koilpatti are given below :—

Aduthurai.—10,000 lb. per acre of green fodder.

Palur.—14,000 lb. per acre.

Koilpatti.—*Ipomoea hispida* was tried both in red and black soils as an unirrigated crop for one season only and was promising with 10,155 lb. on red and 3,158 lb. on black soils. Ipomoea grown as a mixture with fodder sorghum (AS 3,355) on the Agricultural Station, Aduthurai, in the vegetable area were 6,875 lb. and 23,846 lb. per acre, respectively.

(4) *Subterranean clover* (*Trifolium subterraneum, Linn*).—This plant is a native of Southern Europe and is also found in the Azores, most frequently in light sandy soils. It has been introduced into Australia and several parts of the United States of America and has made a very good pasture plant.

Early in 1938, a small quantity of subterranean clover seed obtained from the Okara N.W.Ry. (Distt. Monttgomery) was tried at the Government farms in Nilgiris district. The plant grew well flowered profusely and set seed only at the Government Botanical Gardens, Ootacamund.

About 15 oz. of seeds were collected. The seeds were tried at the Agricultural Research Station, Nanjanad and Government Botanic Gardens, Ootacamund. At Ootacamund and Nanjanad germination started in eight days and was completed in 18 days after sowing. Though the growth was slower during the ensuing cold months, the plants were not appreciably affected by frost. The plants commenced flowering in March-April and seeded during May-June at the Government Botanic Gardens, Ootacamund. At the Agricultural Research Station, Nanjanad, seed formation was noticed from the middle of June. Cultivation was mostly rainfed. Light irrigation by hand-watering was given at weekly intervals during dry weather. The clover was observed to be nearer to lucerne than to grass in point of relish or selective feeding.

(5) *Trees and shrubs of fodder value.*—Generally speaking, fodder from trees and shrubs in Madras must be considered as scarcity fodder. An exception is the practice of feeding pods of *Acacia leucophloea* Willd (Syn. *A. alba*) to high grade cattle in the Kangayam area of Coimbatore district, where expert breeders say that they give an extra bloom to the coat of the animal which means a higher sale value. In the Salem and North Arcot regions, there is a breed of cattle which feeds almost exclusively on the shoots and leaves of *Albizzia amara*. Boiv. even when grass is available. (K. C. Jacob, 1942.)

Leaves of *Erythrina indica* (both thorny and thornless) were fed to milch cows at the Central Farm. Coimbatore, during March-April 1950 as an experimental measure to find out if addition of the green leaves of *Erythrina indica* would increase milk yield and fat content. The cows in the experimental group received 10 lb.

of the leaves besides the usual concentrate and bulky fodders. The result of the experiment showed that no advantage was derived by inclusion of the leaves in the feed, either in milk yield or fat content.

The view generally held by forest officers is that tree and shrub fodder is taken mainly to meet abnormal conditions. It is likely to remain in demand at special seasons so long as the cattle population remains excessive and until measures are taken to ensure the reservation of adequate stocks of dry season fodder by cattle owners. As pasture management improves, and methods for the storage of excess forage produced during the monsoon become more popular, demand is likely to decrease and the ultimate objective should be to eliminate altogether the use of tree or shrub leaf fodder, since lopping at the period of maximum activity of the plant cannot but be detrimental to its health. In the meantime the policy is to grow fodder trees along with other species in all forest plantations in the dry districts so as to create a reserve against possible seasons of shortage. Where the problem is more acute, rotational lopping of selected species is indicated.

Other plants that have been noted as being popular for fodder were *Albizzia lebbeck*, Benth, *Azadirachta indica*, A Tuss, *Bombax malabaricum*, DC, *Dalbergia latifolia*, Roxb, *P. Santalinus*, LF, *Santalum album*, L and *Tamarindus indica*, L. *Eriodendron anfractuosum*, DC, *Pterocarpus marsupium*, Roxb. The bamboos, *Rambusa arundinacea*, Willd, and *Dendrocalamus strictus*, Nees are lopped extensively in north Salem in seasons of fodder scarcity. "Other trees and shrubs of fodder value are *Bassia longifolia*, Linn, B. *latifolia*, Rox, *Mangifera indica*, *Spondias mangifera*, Willd, *Moringa pterigosperma*, *Gaertn*, *Cedrela toona*, Roxb, *Erythroxylon monogynum*, Roxb (Basterd sandal), *Gauzuma tomentosa*, Kunth, *Ficus glomerata*, Roxb, *F. religiosa*, L. *F. bengalensis*, L, *F. infectoria*, Roxb, *Artocarpus integrifolia*, L. *Sesbania grandiflora*, Pers, *Eugenia jambolana*, Lam, *Thespesia populnea*, Cav, *Poinciana regia*, L. *Pithecolobium saman*, *Bauhinia purpurea*. (Ayyar A.K.Y.N. 1944.)

NUTRITIVE VALUE AND PALATABILITY.

Apart from the inadequate supplies of fodder, the quality of fodder judged from its nutritive value is also poor. A substantial portion of the supplies, representing 21 million tons, is the cereal straw left over after threshing grains. Cereal straw has only poor nutritive value for growth as well as for milk production. The nutritive ratio (i.e., the ratio between the digestible crude protein and the non-proteins) furnishes one index by which the suitability of various fodders may be judged. For milk production, the nutritive ratio of the ration should not be wider than 1 : 10 and the higher the milk yield, the narrower should be the ratio. Dry fodder like paddy straw which is abundant in the Madras State has a nutritive ratio of 1 : 40.

Several high yielding and nutritious grasses, like Guinea grass. Napier grass and Rhodes grass with nutritive ratio between 1 : 12 and 1 : 10 were introduced, as reasonably good sources of nutrients for milch cattle. Lucerne or Alfalfa, with a nutritive ratio of 1 : 4 or 1: 6 is ideal for milk production.

Investigations made at the Coimbatore Agricultural Research Institute have indicated a wide range of mineral deficiencies in the fodder grass in the different parts of the Madras State and the need to supplement the cattle ration with calcium and phosphorus.

The chief factor, however, in the selection of the fodder is its palatability. Chemical composition comes next. From the point of view of feeding animals, the most important constituents are (1) Carbohydrates, (2) fats, (3) proteins, (4) minerals and (5) vitamins. Most of our fodders contain sufficient supplies of minerals. The fodders and sunlight give all the vitamin the animal wants. The carbohydrates comprise cellulose, starches, sugars and gums, the last three being easily digestible. Oils and fats are present in all fodders in small quantities. Oils and fats possess greater food value than carbohydrates. The nitrogen is supplied by proteins which are essential for life. The value of different fodders is judged on the basis of energy supplied by the carbohy drates, fats and proteins as follows:—

1 Unit of carbohydrates .. .. 1 Unit of energy.
1 Unit of Protein .. .. .. 1 Unit approximately.
1 Unit of oil or fat .. .. .. 2·3 units approximately.

The composition of the different fodders is indicated in the following table :—

Name of the fodder grass.	Moisture per cent	Ash per cent.	Protein.	Fat.	Fibre.	Carbo-hydrates.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Rice straw (mean) ..	9·85	16·30	3·34	1·46	3·47	37·85
Ragi straw „ ..	9·885	12·102	2·187	2·374	28·221	44·878
Bajra straw „ ..	7·072	8·045	1·942	1·335	37·632	43·648
Tenai and *varagu* straw (mean) ..	8·715	10·050	1·969	2·552	28·840	47·599
Chengaligaddi (Iseilema Anthephoroides)	7·23	11·08	4·26	1·99	32·17	43·27
Nanabalugaddi (Eremopogon foveolatus stapf)	7·53	12·05	3·39	1·66	32·43	42·94
Nendragaddi (Sehima Nervosum) ..	6·87	18·79	2·93	1·47	32·04	37·90
Yendrakayalu (Ischaemum rugosum) ..	7·33	8·01	4·64	1·34	33·33	45·35
Pandibellum (Heteropogon Contortus Beauv) ..	6·80	5·31	2·46	1·41	34·48	49·54
Poonula gaddi (Eragrostis bifaria) W	8·16	9·97	2·50	1·77	33·94	43·66

Name of the fodder grass.	Moisture per cent.	Ash per cent.	Protein.	Fat.	Fibre.	Carbo-hydrates.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Guinea grass (Panicum maximum) Jacq ..	64·57	4·58	1·62	·83	13·00	* 15·40
Napier grass ..	18·53	8·13	5·84	1·29	27·56	† 39·00
Do. ..	87·22	1·92	1·64	0·31	4·27	‡ 4·64
Teff grass (Eragrostis abyssinica) ..	6·57	9 20	8·38	1·63	35·37	‖ 38·85
Teosinte (Euchlaena mexicana) ..	2·71	9·72	3·66	2·38	31·25	‖ 50·28
Kikiyu grass (Pennisetum clandestinum) Hahst ..	8·09	14·83	9·99	3·46	21·95	‖ 43·68
Efwatakala grass (Melinis minutiflora)	71·00	2·34	2·92	0·61	8·05	15·08
Lucerne	10·00	11·20	20·16	1·35	19·80	43·49
Pillipesara	10·73	13·40	11·42	1·26	22·06	41·43
Berseem	11·76	11·98	14·95	2·26	21·60	37·45
Agathi leaves ..	10·00	10·46	30·13	2·01	5·10	42·30
Nallamada (Avicennia officinalis L).	8·64	12·86	11·34	..	..	..
Chirathelathiga (Derris uliginosa, Benth)	5·72	6·84	16·42	..	..	..
Yepi (Hardwickia binata)	7·78	9·14	10·79	5·21	28·21	38·87
Sunnhemp	79·00	22·89	2·04	0·78	0·63	14·66
Ragi	73·00	4·06	4·27	1·35	8·10	9·22

* Fresh grass. † Dried. ‡ Fresh grass. ‖ Hay.

All the tree leaves have a high crude protein content and are comparable to berseem and lucen certain cases. The calcium-phosphorous ratio in leaf fodder is high varying 5:1 to 16:1.

The chemical composition of the tree leaves are indicated below—(T. V. Reddy—1949).

Species.	Common names.	Crude protein.	Cao.	P2O5
Adina cordiolia	*Manja Kadambai*	15·26	2·41	0·26
Bauhinia Variegata L ..	*Mandarai*	13·15	3·50	0·04
Azadirachta indica A ..	*Neem*	15·31	5·53	0·48
Ficus religiosa L	*Peepul*	12·68	4·58	0·47
Ficus infectoria	*Kalalai*	10·90	2·92	0·45
Zizyphus Jujuba Lam ..	*Ilandai*	12·80	4.23	0·76
Dalbergia sissoo Roxb ..	*Shishan*	16·26	4·73	0·54
Acacia catechu W & S ..	*Sundra*	11·81	4·65	0·19
Hardiwickia binata Roxb.	*Yepi*	10·79	4·10	0·24

The composition and nutritive value of the more common fodders are discussed below :—

Name of fodder.	Moisture.	Ash.	Proteins.	Fat.	Fibre.	Carbo Hydrates.	Nutritive values.
Sorghum green ..	69·52	3·67	1·36	0·48	10·45	14·81	1 : 11·7
Maize green ..	88 92	1 88	1·13	0·31	3·11	4·65	1 : 4·7
Lucerne	10·00	11·20	20·16	1 35	19·80	43·49	1 : 2·3
Guinea grass ..	64·57	4·58	1·62	0·83	13·00	15 40	1 : 10·7
Fresh Napier grass	87·22	1·92	1·64	0·31	4·27	4·64	1 : 3·8
Pillipesara ..	10·73	13·40	11·42	1·26	22·06	41·43	1 : 3·9
Straws of cereals.							
Rice	10·77	16·13	3·27	1·42	29·43	38·98	1 : 12·9
Sorghum ..	14·20	9·26	4·53	1·71	32·91	51·59	1 : 12·3
Ragi	12·37	9·68	2·82	1·51	24·29	49·4	1 : 19·0

Sorghum straw is better than that of rice. Ragi straw is considered poor and inferior to rice straw. Guinea grass is relished better than Napier grass which develops to woody stumps when left to grow old. Maize is a good and palatable fodder crop when cut and fed at the time of formation of cobs. Lucerne, *pillipesara* and sunnhemp are good leguminous fodders relished well by animals.

SUMMARY OF RESEARCH AND THE FUTURE.

The Fodder and Grazing Committee concluded thus in 1947 : " In the first place the assumptions about yield per acre should be carefully scrutinized and the data for production of various classes of fodder and grass correct. The proportion of the total animal population should be determined, if possible taluk by taluk . . . the standard ration per each region computed . . . the qualitative value of the ration in each taluk should be examined and deficiencies in intake of protein, minerals, salts and vitamins should be carefully registered. Further it is desirable to study the trend of changes of population, fodder production and ration over a period of some length. When these studies have been made and the various important correlations fully determined, it should be possible to frame scientific policies for each region and sub-region. Till then it will be unwise to say how far deficiencies should be met by import of fodder, by increasing production of fodder or grass, by reduction of the animal population or by more careful and thorough utilization of the available fodder and grazing."

The summary can better be expressed in the words of Mr. G. N. Rangaswami Ayyangar (1940) : " It would be useful at this stage to sum up the general position of fodder crops in the State. In the Visakhapatnam district, apart from the straw from major foodgrains, rice, bajra, and ragi, and to a lesser extent, the straw from sorghum, korra, and samai that are utilized for cattle, fodder crops as such are not raised to any appreciable extent. The hulms and Bhusa from pulse crops like blackgram, greengram and horsegram and groundnut are often utilized. Pillipesara is becoming popular in paddy lands both as green manure as well as fodder. In the deltaic portions of Godavari. Krishna and Guntur, pillipesara is a popular green fodder, while sunnhemp is another fodder crop usually made into hay and stacked along with paddy straw. In the dry lands of these districts, since what little grazing was available once is all gone now, sorghum, either pure or mixed with pillipesara, is grown as a fodder crop in the early season and as a grain crop in the late season. In the ceded districts, the area cropped per pair of cattle is so large that in normal years the ryot gets all the fodder he needs from the sorghum straw on this area. He is, as a rule, fully aware of the fodder value of mixing legumes with his cereal straw, but, with seasons so uncertain, he is unwilling to risk pulling down his sorghum yields by having such mixtures. In the black soils of the south, in Madurai,

Ramanathapuram and Tirunelveli, the ryot usually reserves a portion of land for growing rainfed sorghum as a pure fodder crop, using very high seed rate to get the stalks thin and fine. On the red soils, however, sorghum is a grain crop. Here, it is often mixed in the pulses if rainfed and grown pure only when raised under wells. The fodder supply may be said to be adequate in these districts, but the same cannot be said of Tanjore and parts of South Arcot where paddy straw is the mainstay for cattle. Pillipesara has been a success here, so that it is worth while to advocate growing it either pure or mixed with fodder sorghum in paddy lands from January till June where there is no paddy crop. Guinea grass or Napier's fodder also can be planted along bunds and sides of water channels. In the garden land districts of Coimbatore, Salem and North Arcot, sorghum, both as a rainfed as well as an irrigated crop, is the mainstay for fodder. Pulse mixtures too are common practice. The merits of lucerne are getting to be well known and recognised in Coimbatore. In the town itself, a regular agency has sprung up, supplying lucerne for milch cows and jutka horses. On the humid west coast (Malabar and South Kanara) green grass is available from July to December and although the cattle are usually half starved for the rest of the year, from January to June, the raising of fodder is hardly ever practised. There seems to be a good scope here, for a wider use of forage crops like green bajra and cowpea, converting them into silage for use during the dry months from January to June. In the Nilgiris also, the need for raising fodder crops is not yet felt, although here too, suitable crops are available such as samai, teosinte and lucerne."

The causes of the present fodder scarcity in areas outside reserved forests are (1) progressive deterioration of pastures in *porambokes* and other lands, (2) breaking of pasture lands for cultivation, (3) increase of area under current fallows, (4) a probably large extent under non-food crops and (5) a very small area about 1·5 per cent of the net area sown under fodder crops.

As regards the future prospect, it is safe to assume that most of the fodder requirements of the State would continue to be met from an extension of the area under the crops reviewed above, although, of course, the possibility of new introductions is not excluded. The Agricultural Department has demonstrated the utility of fodder crops like sorghum, maize, guinea grass, Napier's fodder, lucerne and *pillipesara*. Further lines of useful activity apart from the continuance of advice regarding the most suitable fodder crops in different localities, under dry and irrigated conditions, would be in the evolution of more strains of fodder sorghum, suited to particular tracts, and the isolation of better yielding types of other fodder and pasture grasses. In what may be termed "suburban farming areas", there is good scope for an intensive commercial cultivation of fodder crops such as maize and lucerne and supplying such fodder for milch stock in the towns. Under

such intensive cultivation, the question of rotation assumes less importance than in truly rural areas where, with the extensive type of dry land farming, it is vital to conserve the fertility of the land by judicious rotation of crops.

The solution of the fodder problem is the solution of the wider problem of bringing about a general improvement in ordinary farming practice. A partial solution of this problem would be achieved if it were more generally realised that the quantity of cattle manure produced on a given holding is more a function of the amount of fodder fed and of litter used than the number of cattle now being kept. It is therefore necessary to increase the yield of fodder to provide a sufficiency of feed for the cattle which must be kept and to supply more litter in order to increase the amount of cattle manure for which there is dire need. The systematic botanist has made a study of the yield, adaptibility and palatability of many fodder grasses and much more needs to be done. It is, therefore, necessary to make more detailed studies about pasture grasses on the lines of grass land husbandry in Scotland.

The free cutting of hill grasses by local cultivators in certain forest areas has been permitted by the Forest department. To afford facilities and encourage the cultivators in the growth of fodder crops as such, the Government charge no water rates for them, subject to certain conditions. This valuable concession is made known through leaflets. In Malabar where concentrated rainfall makes for the lavish vegetation in a part of the year only, steps have been taken to convert the excess grass into silage and thus tide over the long spell of dry weather from January to May when cattle have little or nothing to eat. Ragi straw hitherto considered as indifferent fodder has been successfully converted into valuable silage.

Fodder and Grazing Committee—Constitution and Contribution.

At the instance of Government of India, The Government of Madras, in 1938, constituted an advisory committee called the "Fodder and Grazing Committee". The member of the Board of Revenue in charge of Panchayat forests is the ex-officio chairman. The Secretary of the Board of Revenue dealing with Forest Panchayats is the ex-officio secretary of the committee. The Director of Agriculture, the Chief Conservator of Forests, the Chief Engineer for Irrigation, the Director of Animal Husbandry and the Live Stock Development Officer are the ex-officio members. A few prominent non-officials and officials who take an interest in cattle and their feed are also members of the committee.

This committee considers important schemes relating to cattle and their fodder supply for suitable action or sanction. At the

instance of the committee, a report was prepared on the condition of the panchayat forests of the Madras State and the measures that could be adopted to preserve and improve them. The committee published Memoirs containing statistics of the existing livestock and of the fodder production. An Atlas illustrating the same was also prepared.

The most important finding of the committee is given below:—

"The committee considers that it is time to design and inaugurate a definite policy to improve the feeding of cattle in the State. It considers that the steps suggested in the Memoirs should be undertaken and that action should not wait until they are complete. It observes that the problem, as it presents itself in the light of the Memoirs, is one of ecology requiring a balanced use of the land which takes full account of the natural conditions and the requirements of the animal population. The problem is, therefore, not one for a committee like the Fodder and Grazing Committee dealing with the particular aspects of land use, but one to be tackled by a Land Utilization Board, working both through the existing departments and through a department of soil and water conservation. The committee repeats this recommendation for the early formation of a Land Utilization Board and suggests that the Board supervise the reclamation, development and conservation of land and water resources and that it should take pains to ensure that in every project, the needs of the animal population are given proper weight. It should see that when the land is reclaimed, irrigated and colonised, the cultivation of fodder is promoted to the extent required by a plan of balanced development. Pending the institution of a Land Utilization Board, all departments dealing with irrigation and other projects should be urged to make a special provision for fodder cultivation."

GRASSES.

Grasses form the most important fodder, being the primary food for all animal creation. Though there are hundreds of grasses only a small number are valuable for cultivation for fodder purposes and a few for pastures. In the Botany Section of the Agricultural Department, Coimbatore, studies on grasses were begun as early as 1929 and since then *surveys* of grass flora of different districts and *trials* of many exotic and indigenous grasses formed important items of work.

Surveys.—The first surveys were carried out in parts of Salem, South Arcot, Tanjore, Godavari, Visakhapatnam, Nilgiris and Ganjam districts. During these surveys 170 species were collected and analysed. Some of the promising ones were given trial in observation plots at Coimbatore for fodder and pasture purposes. Grass floras of Chittoor, South and North Arcot, and Travancore were studied and elaborate notes were published. Thereafter a fodder survey in Chingleput, Travancore high ranges

and Kangayam tract in Coimbatore was made. In Travancore it was noticed that *Kikiyu grass* (*Pennisetum clandestinum, Hochst*) and *Golden Crown grass* (*Paspalum dilatatum Poir*) had spread about 80 square miles forming a good pasturage.

These surveys resulted in the preparation of a "*Pasture Grass Map of South India*" showing therein the predominating annuals and perennials of each district. This map serves as a useful guide and offers basis for any future improvement work on pasture grasses in the districts.

Trials of exotic and indigenous grasses.—The above surveys facilitated collecting and trying many of the indigenous grasses in observation plots. Seeds of grasses were also received from different countries outside India and all these were given series of trials. Grasses tried so far approximate to over 200 species both exotic and indigenous. Most of these were tried under rain-fed conditions for selecting promising and suitable grasses for pastures in the plains. Regular observations on growth habits, yield, drought resistance, and palatability were made and sixteen species have been selected for large-scale field trials. Since these have proved to be successful they are being multiplied and distributed. A short account of each of these sixteen species and a few more that are under trial are given below. Many of these grasses have been under trial in agriculturists' fields and reserve forests with the co-operation of Forest department and have proved to be of importance in improving grazing areas.

EXOTIC GRASSES.

Panicum antidotale, Retz. (*Australian drought resistant grass*).—The seeds of this were first received in 1942 from Australia. During the trials this grass was noticed to do exceedingly well in comparison with other grasses and provided green pasturage in summer when the other grasses dried up. This is reported to do well in many of the research stations and many private correspondents have certified its performance. It is found to grow well in all soils except heavy and sandy soils. At present this is a very popular grass in the State and there is an increasing demand for the seeds. The drought resistance of this grass is remarkable. The grass yields from 15,000 to 20,000 lb. under rainfed conditions in two to four cuttings per year per acre. It responds well to irrigation also. The seeds keep viable for over five years.

Cynodon plectostachyum; Pilger (*Giat Star grass*).—This is a native of Africa introduced in 1940 from seeds received from Pasture Research Station, Pretoria, which resembles the common *hariali* or the doub grass (*Cynodon dactylon*, Pers). This grass can be propagated both by seeds and slips; but it is easily multiplied by means of slips as the seed setting is poor. The grass has a good spreading habit and is vigorous in growth. It is possible to take the first cut four months after planting and the subsequent

ones at intervals of 60 to 75 days except in the summer months (15th February to 15th June). It gives an acre yield of 10,000 to 15,000 lb. in three or four cuts. This will be suitable as a pasture grass in areas with rainfall over 30 inches. This grass has been considered as the best and most nutritious grass in ranching country in Africa. The hay of this grass is highly relished and is even said to be as nutritious as to meet the requirements of cattle even when fed alone.

Due to divergent views regarding the palatability and toxicity of this grass, the analysis of this grass at various stages of growth for its hydrocyanic acid content and feeding value at shot-blade stage, followed by actual feeding trials, were conducted. The Giant Star grass is capable of being cultivated both under irrigated and dry conditions. The grass is found to be a quick grower under Coimbatore conditions. The grass was studied well on chemical aspects also and it was found to possess good pasture value. The grass is noticed to contain hydrocyanic acid at all its different stages of growth but the quantities were far below the accepted lethal dose of 0·20 per cent.

Actual feeding trials conducted at various stages of its growth also confirm that it could be safely fed to cattle. In the wilted stage its palatability is neither impaired nor toxicity increased.

In addition to the pasture value, the grass possesses soil binding properties and can be effectively used in preventing soil erosion.

Brachiaria mutica Stapf (*Water grass*).—A very valuable grass introduced in Coimbatore from Quilon in 1940, it thrives in all soils provided irrigation is available. In Koilpatti it has given a higher yield than Guinea grass under irrigation. In Central Farm, Coimbatore, the yield of this grass in a single cutting was found to be 31,350 lb. in one acre. The total yield per acre per year is over a lakh and half pounds. Comparative trials with Guinea grass are under progress. Animals relish this grass better than Guinea or Napier grass and the feeding value favours well with the other irrigated grasses. The water grass comes up very well in marshy areas and hence can be utilized to reclaim swamps and seepage-affected lands. It was tried for this purpose in four villages in Madurai district along the Periyar tract and was found successful. It may be advantageously grown along irrigation and drainage channels in wet lands.

Rhodes grass (*Chloris gayana, Kunth*).—A perennial grass of South Africa growing to four to five feet high, is easily raised by seeds. At Coimbatore it failed on a field scale. At Hosur it failed so badly due to drought in 1919 that its cultivation was given up. At Hosur its average yield was 10,800 lb. per acre per year. Seed material of Rhodes grass was received from different places as Africa, Australia, America, Delhi and Bangalore and these are under trial again at Coimbatore. Some of them are promising. It grows well in certain soils like rich loam and alkaline soils and is unsatisfactory on clay and sandy soils.

Pennisetum-clandestinum, Hochst. (*Kikiyu grass*).—This is a native of tropical Africa. A perennial runner, it got introduced in Nilgiris, Kodaikanal and Anamalais and has established in these areas. This was first tried in Central Farm in 1924 and yielded 19,800 lb. per acre. IIn 1926 this was found not to suit periodical cuttings for fodder but was more suitable for pastures. At Nanjanad it grew well as a soil-binding grass on bunds and sides of water channels, and is able to stand both frost and water logging. But recently it is felt that this grass is too rapid in its growth and is found to dominate the cultivated fields becoming a noxious weed and eradication of this is a great problem. This grass, though of great pasture value in hills, is not suited for growing near cultivable area since it becomes a weed. It may be grown with advantage in sloping forest lands which are subjected to erosion.

Sorghum sudanense, Stapf. (*Sudan grass*).—This grass was noted as promising at Hagari and at Central Farm, Coimbatore. In the July sown plot the October cutting weighed 9,100 lb. per acre. Subsequently this fodder grass of America was found to have no future in Madras State.

Melinis minutiflora, Beauv (*Etwatkala grass*).—Introduced from Rhodesia in 1922, it grew on the Central Farm for five years and gave, under irrigation, an yield of 17,000 lb. per acre per annum. But the grass is reported to be foul smelling in certain stages and is rejected by cattle on occasions. As *Guinea* and *Napier* grasses were proved to be definitely superior, the cultivation of this was discontinued. In Jamaica it was claimed that the grass has repelling properties and hence suited for anti-mosquito purposes. It was even termed the 'snake fighting grass'. A series of trials conducted by the Botany Section to find out whether this species can be used for such purposes showed that the grass has not got any of the virtues attributed to it.

Eragrostis abyssinica, Shrod (*Abyssinian Teft grass*).—This native of Transvall, was tried in Central Farm. This was relished by cattle but could not stand cutting or grazing. Hence it was given up.

Pennisetum polystachyon Sch. (*Thin or dry Napier*).—This grass was introduced at Coimbatore from Mysore and has been tried for rainfed areas. Under rainfed conditions at Coimbatore, it has repeatedly failed but its introduction in West Coast Agricultural Research Stations has been so successful that it has become more or less naturalized to that region. Under irrigation at Tirurkuppam it gave a good yield of fodder, greatly relished by animals.

INDIGENOUS GRASSES.

Cenchrus ciliaris, L. (*White Kolakattai*).—This is a very popular grass of Coimbatore district and is the staple feed for the Kangayam breed of cattle. This is a fairly drought resistant

grass possessing power of regeneration immediately after rains. The grass is well relished by cattle and is naturally established round about Coimbatore. At Hosur it was tried in 1926 and was less drought resistant than the Spear grass (*Heteropogon contortus*) Beauv. In Guntur it did not come up well. In the only trial in Samalkota it was successful. At Chintaladevi also it was quite good though late in establishing. From 1925 it was grown in Central Farm with great success. The grass can be grown both under dry and irrigated conditions. This is one of the few grasses which responds to slightest rain. Under rainfed conditions it has yielded 40,000 lb. per acre in four cuttings. Under irrigated conditions it has yielded 70,000 lb. to 80,000 lb per acre. This is one of the best pasture grasses and is very well suited to areas with about 25 inches rainfall and with soils rich in calcium.

Cenchrus setigerus, Vahl (*Karuppu Kolakattai*).—This is another species of Cenchrus which is as good as the former but with poorer distribution. It is a slow grower compared to C. *ciliaris* and does not stand drought. The viability of the seeds is also very poor. The grass is said to be relished better by animals and due to the low diffuse growth is best suited for pasture.

Iseilema laxum. Hack (*Chengala gaddi*).—The most popular grass of Nellore area and is the staple pasture grass for the Ongole breed of cattle. It is drought resistant and is much relished by animals. Chemical analysis also revealed it to have a high nutritive value. For all these reasons, this grass deserves to be grown in large areas.

Iseilema anthephoroides Hack.—This *Chengali* (with fine foliage and flowers) is abundant in heavy moist regada clay but though not very common all over the reserves in Nellore district, is suitable for grazing areas. At Coimbatore, however, this grass did not thrive well.

Heteropogon contortus, Beauv. (*Spear Grass*).—This grass covers about 800 acres in the grass lands of Hosur giving an average yield of 1,100 lb. of hay per acre. After flowering the spear-like awns are a source of nuisance to animals. It is a good pasture grass, stands drought well and is best suited for hay purposes.

Sehima nervosum, Stapf. (*Nendra gaddi*).—This is one of the forest grasses which grows luxuriously above 2,000 feet. It grows in very large clumps producing probably the largest number of tillers in any of the Indian grasses. The grass possesses very soft culms and leaves so that cattle prefer it to all other grasses. The yield was 12,000 to 15,000 lb. per acre and it is suitable for making hay also.

Eremopogon foveolatus, Stapf.—This is found in the reserves on soft *regada* clay and is considered to be suitable as a fodder grass. It requires fertile soil and is able to stand some amount

of drought. In Coimbatore it has yielded 12,000 lb. per acre in two cuttings under rainfed conditions. As a pasture grass this is of value since the grass forms good clumps with soft foliage and culms.

Chloris bournei, Rang and Tad.—This is a well-known grass which thrives best in black-cotton soils and alkaline patches. Under dry conditions it has yielded 56,400 lb. per acre in Coimbatore in three to four cuttings. The grass is relished by cattle before flowering.

Chloris barbata, SW.—This comes up in all soils and is specially suited for alkaline areas. Often a weed in cultivated field, cattle relish the grass before flowering.

Chionachne semiteres, Fischer.—Under rainfed conditions this grass has yielded 15,000 lb. in one acre in two cuttings. The leaves become coarse in later stages and hence have to be cut and fed when young. The grass does not set seeds freely and the few seeds that are set do not germinate readily. But it is easily propagated by slips.

Chionachne Koenigii, Thw.—This yielded 15,000 lb. in Coimbatore under rainfed conditions and does better under irrigated conditions. Cattle relish this grass better than the former. It has a preference to heavy soils and comes up in black cotton areas. It is cultivated by a few ryots in parts of Godavari delta and responds to good manuring.

Amphilophis pertusa, Stapf.—This is a grass esteemed universally for pasture value. The flower when bruised gives a light pungent smell which distinguishes this plant easily from *Eremopogon foveolatus*, Stapf. It has a spreading habit and comes up in all dry areas.

Dichanthium annulatum, Stapf.—This is another species, suitable for pastures and establishes well in red loamy soils with about 30 inches rainfall. It spreads on the ground and ascends geniculately. Besides being a good pasture grass, it stands cutting. It is much liked by cattle and said to increase the milk yield.

Andropogon pumilus, Roxb.—This is suited for heavy black-soil areas. Though it does not put forth much leafy growth, it is one of the few grasses that come up under that soil conditions. The grass when mature has a reddish colour and is easily identified by the forked inflorescence. Cattle eat the grass at all stages of its growth.

The acre yield and composition of these grasses are given in Statements I and II.

STATEMENT I.—*Comparative yields of some promising, indigenous and exotic grasses.*

Serial number and name of the grass.	*Common or Vernacular name.*	*Yield per acre in lb.*	*Number of cuttings.*	*Green or hay.*	*Remarks.*
1 Pennisetum purpureum, Schum.	Napier grass ..	179,200	5	Green ..	Irrigated, excellent fodder grass suited for places of moderate rainfall.
1-a Brachiaria mutica, Stapf ..	Buffalo grass ..	18,000	5–7	Do. ..	Irrigated. Is found to yield more than Guinea grass.
2 Cynodon plectostachyum Pilger.	Giant grass ..	60,000	3–4	Do. ..	Rainfed, excellent grass, good soil binder.
3 Chloris, Bournei, Rang and Tad.	....	56,400	3–4	Do. ..	Semi-dry. Thrives best in black-cotton soils.
4 Cenchrus ciliaris, L.	Kolakattai ..	40,000	3–4	Do. ..	Rain-fed. Staple grass in Kangayam tract. Under favourable condition yields more.
5 Panicum maximum, Jacq ..	Guinea grass ..	21,000	2	Do. ..	Rain-fed, under irrigation it gives approximately 50 to 70 thousand lb.
6 Panicum antidotale, Retz ..	Nassium pillu ..	15,000	2	Do. ..	Rain-fed, Good drought resistant, performs well under irrigation.
7 Chionachne semeteres, C. Fisch ..	....	15,000	1–2	Do. ..	Rain-fed.. Relished by cattle when young.
8 Chionachne Koenigii, Thw ..	Sukhudhabha ..	15,000	1–2	Do. ..	Rain-fed. Very promising under irrigation.
9 Enteropogon monostachyos, Schum.	Kanniapillu ..	13,000	2	Do. ..	....
10 Eremopogon foveolatus, Stapf ..	....	12,000	2	Do. ..	Comes in dry conditions also. Requires good soil.

STATEMENT II (*a*).—*Composition of some common fodder grasses.*

Serial number and name.	*Moisture.*	*Ash.*	*Crude Protein.*	*Ether Extractives*	*Crude Fibre.*	*Carbo-hydrates.*	*Total.*	*Lime (Cao).*	*Phosphoric acid P2 0₅.*	*Insolubles.*
1 Panicum antidotale, Retz. ..	5·98	10·98	7·46	1·31	25·83	48·44	100·00	0·901	0·917	4·55
2 Cenchrus ciliaris, L.	7·11	13·77	6·45	1·74	23·69	47·24	..	0·626	0·613	8·11
3 Cenchrus setigerus. Vahl. ..	7·30	13·88	5·55	1·78	24·15	47·34	100·00	0·697	0·696	9·67
4 Dichanthium annulatum, Stapf.	6·53	13·74	5·54	1·82	24·98	47·39	..	0·579	0·505	9·44
5 Enteropogan monostachyos, Schum.	8·08	9·20	4·32	1·61	30·02	46·77	..	0·358	0·678	5·57
6 Eremopogan foveolatus, Stapf.	6·83	8·84	4·30	1·70	29·17	49·16	..	0·326	0·252	6·97
7 Chloris Bournei, Rang & Tad.	5·50	8·61	4·26	0·97	31·85	48·81	..	0·378	0·607	5·15
8 Sehima nervosum, Stapf. ..	6·28	19·00	4·03	1·45	25·83	43·41	..	0·791	0·394	15·65
9 Leptochloa obtusiflora, Hochst.	6·88	7·56	3·99	1·19	36·51	43·87	..	0·523	0·793	4·36
10 Iseilema laxum, Hack ..	6·49	10·49	3·14	1·31	31·84	46·73	..	0·375	0·469	7·81
11 Andropogon pumilus, Roxb ..	7·66	11·03	2·61	1·54	23·91	53·25	—	0·368	0·009	8·69

STATEMENT II (*b*).— *Results of analysis of samples of green fodders.*

Particulars.	*Moisture.*	*Ash.*	*Crude Protein.*	*Ether extractives.*	*Crude fibre.*	*Carbohydrate (by difference.)*	*Lime (Cao).*	*Phosphoric acid. P2 0₅.*
1 Digera arvensis, Fofak	4·61	21·37	22·64	2·48	12·05	36·85	3·99	0·61
2 Amarantus, viridis, L.	5·55	25·73	18·88	2·37	13·58	33·89	3·56	0·01
3 Celosia polygonoides, Retz	4·50	18·48	18·24	2·35	16·56	39·87	2·23	0·62
4 Commelina benghalensis, L.	5·28	32·04	13·42	2·10	11·34	35·82	5·26	0·46
5 Cyanotis cucullata, Kunth	4·15	43·11	20·18	2·54	5·09	24·93	6·52	0·42
6 Portulaca oleracea, L.	4·86	29·45	21·19	3·72	6·67	9·74	3·53	0·55
7 Alysicarpus sp.	5·11	14·89	19·97	3·67	9·74	46·62	2·24	0·80
8 Indigofera ennaeaphylla, L.	4·64	20·11	17·09	2·58	15·16	40·42	6·90	0·59
9 Rhynchosia, minima, DC.	5·30	16·03	20·69	3·23	13·77	40·98	2·05	0·73
10 Mucuna, prurita, Hook	7·02	8·58	18·30	2·35	26·58	27·17	1·00	0·74
11 Trianthema portulacastrum L.	4·70	24·42	14·03	3·19	14·56	39·10	1·92	0·60

STATEMENT II (c)—*Composition of some common grasses.*

Serial number and name.	*Moisture.*	*Ash.*	*Protein.*	*Fat.*	*Fibre.*	*Carbohydrates.*
1 Iseilema anthephoroides, Hack (Chengali gaddi)	7·23	11·08	4·26	1·98	32·17	43·27
2 Eremopogon foveolatus, Stapf (Nanabalu gaddi)	7·53	12·05	3·39	1·66	32·43	42·94
3 Apluda aristata. L. (Pullirusu gaddi)	7·82	14·77	4·41	2·52	34·64	35·84
4 Chrysopogon orientalis, A. Camus (Karrappa gaddi)	7·79	8·44	4·45	1·13	35·55	42·64
5 Cymbopogon caesius, Stapf (Kamatchi gaddi)	7·85	6·71	2·81	2·33	37·70	42·60
6 Cymbopogon coloratus, Stapf (Botta gaddi)	7·33	6·70	2·27	2·62	36·72	44·36
7 Andropogon sp. (Dabba gogada)	7·02	15·27	2·39	2·38	37·24	45·70
8 Sehima nervosum, Stapf (Nendra gaddi)	6·60	21·20	2·38	1·09	28·63	40·10
9 Ischaemum rugosum Salisb. (Yentrakoyulu)	7·33	8·01	4·64	1·34	33·33	45·35
10 Perotis indica, O. Ktz. (Nakka peethu)	8·41	5·72	4·03	1·87	30·56	49·41
11 Melanocenchris Gracilea nutans Koenmonoica (C.E.C. Fisch)	8·41	12·07	4·63	1·37	26·52	47·00
12 Lophopogon (L. tritentatus Hack)	7·76	19·61	2·37	1·51	29·17	39·58
13 Aristida setacea Retz. (Chipurugaddi)	7·73	7·46	3·32	1·14	36·49	43·86
14 Enteropogon monostachyos, Schum (Kannai pillu)	8·44	7·97	4·33	1·41	33·51	44·34
15 Chloris incompleta. Roth (Kannthari gaddi)	8·38	6·36	5·48	1·24	33·51	45·03
16 Chrysopogon montanus, Trim (Gogada gaddi)	7·97	12·05	2·83	1·51	30·27	45·37
17 Eragrostis bifaria W (Poovula gaddi)	8·16	9·97	2·50	1·77	33·94	43·86
18 Ischaemum aristatum, L. (Erruthota gaddi)	5·36	5·00	4·59	1·48	41·49	42·11
19 Arundinella metzii, Hochst	5·73	4·55	5·21	2·29	37·07	45·15

CHAPTER 14.

SPICES, CONDIMENTS AND PLANTATION CROPS.

Ginger, Turmeric, Cinnamon, Asafoetida, Curry leaf, Mint, Clove, Vanilla, Chillies, Pepper, Coriander, Cardamom, Nutmeg—Varietal, and cultural trials on these crops—Miscellaneous studies. Plantation crops—Tea, Coffee, Rubber, Cryptostegia rubber, Cashew—Varieties, cultivation, products and processes.

General.—Spices are very important in human diet. Added in limited quantities and in suitable combinations to articles of food, they provide the necessary taste and flavour. Even comparitively coarse articles of food are made sufficiently tasty for consumption by the addition of suitable spices. Most of the spices are also considered to help digestion on account of the carminative properties of their constituents and many of the common spices find a place in various medicines.

In spite of the importance of spices in our daily diet and their medical and other uses, these crops producing the various spices have received only very little attention from the agricultural research workers in the country. The total area under the various spice and condiment crops in Madras State is about 690,000 acres. The spices and condiments under commercial or large scale cultivation in this country are chillies, turmeric, pepper, coriander, cardamom, tamarind and ginger. Other spices and condiments that are being grown on a very limited scale in this State are cinnamon, clove, nutmeg, vanilla, mustard and peppermint.

The various spices can be classified into six groups according to the part of the plant from which the spice is obtained, viz., (i) rhizomes and root spices, (ii) bark spices, (iii) leaf spices, (iv) flower spices, (v) fruit spices, and (vi) seed spices. The work on the various spices is given below:—

GINGER (*Zingiber officinale*, Roscoe).

Production and importance.—The normal area under commercial cultivation of ginger in the State of Madras is about 11,350 acres in Malabar, 750 acres in South Kanara and 40 acres in the Nilgiris with a total annual production of about 4,050 tons of dry ginger. The crop is also cultivated on a small scale for the vegetable market in almost all the districts and to an appreciable extent in the districts of Nellore and Cuddapah.

The most important tracts in respect of ginger cultivation in Madras are the taluks of Ernad, Walluvanad, Ponnani and Wynad in Malabar and Kasargode in South Kanara. In the taluks of

Ponnani, Ernad and Walluvanad this spice is one of the most important money crops.

Ginger is not only sold in the Indian market for home consumption, but also figures considerably in our export trade to the tune of about 1,500 tons. It is in great demand in America, and therefore, it has an important place in our present dollar economy.

Climate, soil and cultural practices.—Ginger has been found to grow well from almost sea level to an elevation of about 5,000 feet as in the Himalayan regions. In Madras, it is being successfully cultivated from almost sea-level in the coastal taluks of Ponnani, Chirakkal, Kottayam and Kurumbranad, to an elevation of about 5,000 feet above sea-level in the Nilgiris. However, it is found to come up best in regions or tracts with a plentiful amount of rainfall in the south-west monsoon, a fair amount of rainfall in the north-east monsoon and a comparatively dry period from December to May.

Ginger is found to grow very well in the sandy loams of the taluk of Ponnani in Malabar, as well as in the fairly stiff clay loamy soil of Wynad, and even in the more heavy soils as found in the eastern and northern districts of Madras. However, the crop thrives best in friable loamy soil with a fair admixture of humus. Very gravelly soil is not considered suitable for the proper development of the rhizomes. Ginger grown in Ponnani taluk known as '*Chernad*' ginger is more plumpy and less fibrous than the produce of other areas, and the higher price it fetches is on account of this quality.

While in Malabar, South Kanara and Nilgiris it is grown under purely rainfed conditions, in the other districts it is grown for the vegetable market, mainly as an irrigated crop in garden lands. As an intercrop in coconut plantations, it will be to the advantage of the coconut trees, on account of the deep diggings and heavy application of cattle manure and leaf, which benefit the coconut trees also. In Wynad, ginger is commonly cultivated as an intercrop in younger coffee and orange plantations and also in freshly cleared lands. Along with ginger, root crops, vegetables and pulse crops are also grown as intercrops. As ginger is not attacked by wild boar, root crops grown in between the beds of ginger are free from wild boar attack.

Varietal introductions and trials.—Three commercial types of ginger are known in the Calicut market namely, '*Ernad*', '*Chernod*' and '*Wynad*' but these cannot be called distinct varieties.

Ginger varieties, *Blue Jamaica*, *Yellow Jamaica*, *Trinidad Canton* and *Bengal* were introduced in the Agricultural Research Station, Taliparamba, Malabar. Comparative yield trials of these did not give conclusive results regarding the superiority of any of the varieties over the others, as *Trinidad Canton* gave significantly higher yield in two seasons, *Ernad* in two other seasons, and *Bengal* in one season. It was, however, concluded that *Ernad*

variety is as good as the varieties *Trinidad Canton* and *Bengal* in the matter of yield.

No attempts have been made in this country at evolving new types of ginger by selection, hybridization and other methods.

Agronomic trials and experiments.—The seed rate generally adopted by growers is about 1,000 lb. to 1,250 lb. per acre. A trial at Taliparamba to determine the possibility of reducing the seed rate indicated that lowering the seed rate diminished the yield. The yield per acre was about 5,000 lb. of fresh rhizomes or about 1,000 lb. of dry ginger per acre at Taliparamba.

Manurial trial.—A manurial trial on ginger conducted in Agricultural Research Station, Taliparamba, Malabar with five tons and ten tons cattle manure per acre alone and in combination with 500 lb. and 1,000 lb. groundnut cake respectively did not give any confirmatory results.

Research on storage.—Experiments on the prevention of ' soft rot ' of ginger in storage have been conducted at Taliparamba with different chemicals. These trials showed that treating ginger rhizomes with 0·1 per cent mercuric chloride solution for about two hours before storage will greatly reduce the loss occurring in storage on account of ' soft rot '.

Future work.—Ginger is an important money crop in Malabar covering an area of about 12,000 acres. In order to conduct systematic and comprehensive research on its cultural and the manurial aspects, pests and diseases and methods of curing and preservation, a scheme has been sanctioned by the Indian Council of Agricultural Research and work has already been started at Pattambi, in 1950.

TURMERIC (*Curcuma longa.* L.).

Production and importance.—The average area under turmeric in the Madras State is about 40,000 acres with an annual production of about 69,000 tons of dry turmeric. The most important districts are Guntur (8,800 acres), Kistna (3,700 acres), Malabar (7,600 acres), Cuddapah (5,700 acres) and Coimbatore (3,800 acres).

Turmeric is a very important money crop in the districts of Guntur, Kistna, Cuddapah and Coimbatore and is exported to Bombay, Bengal and foreign countries chiefly Ceylon, United Kingdom and the United States of America.

Climate, soil and cultural practices.—In the Madras State, turmeric is found to grow well in the humid tropical region of Malabar including tracts which are about 4,000 feet above mean sea-level and also in the comparatively hotter and drier regions of the plains.

In most districts the crop is grown generally as a pure crop under canal or lift irrigation, but in Malabar it is grown as a rain-fed crop either pure or as an intercrop in coconut plantations.

In all the districts where turmeric is grown except Malabar heavy manuring of the land prior to planting is necessary.

The following indicates the manure an acre would require in the districts of Guntur, Krishna and Cuddapah districts :—

	Guntur and Krishna.	*Cuddapah.*
Clay or tank silt	30 cartloads.	50 cartloads.
Cattle penning	800 heads.	..
Sheep penning	2,000 heads.	3,000 heads.
Cattle manure	50 cartloads.	50 cartloads.

In Guntur and Krishna districts, the mother rhizomes or 'bulbs' are invariably used for planting, cut longitudinally into two pieces, taking care to see that there is at least one sound 'eye' on each piece. In Cuddapah, the 'fingers' are generally used for planting without cutting, but the longer 'fingers' are broken across into two and planted. In Malabar, both 'bulbs' and 'fingers' are planted. The 'bulbs' are generally considered to be superior to 'fingers' as planting material.

Varietal introductions and trials.—Different varieties of turmeric are not known, though differences in the appearance and quality of the produce of the Circars, Cuddapah and Tamil districts and Malabar are very marked. While the produce of Malabar is generally shrivelled in appearance and has a less attractive colour, that grown in the other regions are plumpy and have a more attractive colour. In world trade, different varieties like 'China', 'Madras', 'Bengal' and 'Cochin' are known. The *China* turmeric is most esteemed in trade circles. *Madras* and *Bengal* are the most common trade turmerics. The *Cochin* turmeric is not the true turmeric but is the produce of *Curcuma aromatica.*

Harvest and yield.—The numbers of fingers vary from ten to forty in a plant and the average yield per acre ranges from 2,000 to 5,000 lb. of cured turmeric. In Malabar, the yield seldom exceeds 2,000 lb. of cured turmeric.

The proportion of bulbs to fingers is about 25 per cent by weight. The proportion of cured turmeric to fresh rhizomes is also about 25 per cent.

Storage and marketing.—The fresh rhizomes have to be cured by boiling and dried for marketing. Before the turmeric is exported, it is polished and coloured. The polishing is done in the main marketing centres in factories and also by hand operated machines. The Research Engineer, Coimbatore, had designed a hand operated polishing machine for turmeric and this is used extensively in the Coimbatore district.

Future.—A survey of turmeric cultivation in the districts of Guntur, Krishna and Cuddapah with a view to suggesting the lines of improving the cultivation of the crop was undertaken in 1948. As turmeric is an important money crop in the Circars, Cuddapah and Coimbatore, it appears necessary that more research work on the crop, particularly on the agronomical and manurial aspects

should be carried out to determine the optimum cultural and manurial practices necessary for high yield. The comparative merits of ' bulbs ' and ' fingers ' as planting material have to be investigated, and trials conducted on the possibility of reducing the seed rate generally adopted in the different tracts. The varieties of turmeric ' China ' and ' Bengal ' should be imported for comparative trials with the indigenous variety, so that, if the exotic varieties are superior, these varieties can be multiplied to replace the local varieties.

CINNAMON (*Cinnamomum zeylanicum. Mees*).

Production and importance.—Cinnamon cultivation in India is about 180 years old. A plantation about 500 acres in extent was then started in Anjarakandy near Cannanore, Malabar and has been giving considerable profits. Very recently about ten acres were planted north of Cannanore, and a thousand plants near Tanur in Malabar. Although the indigenous cinnamon of the Western Ghats growing wild is the same as the cinnamon of Anjarakandy and Ceylon, the bark is far inferior. Ceylon produces the major portion of the world's supply, and the Ceylon quality is considered superior to the cinnamon produced in all other countries.

As the culitivated cinnamon of Anjarakandy is reported to be as good as the Ceylon product, and the demand for good cinnamon in India is considerable, and is being met mostly by imports, there is a considerable need for cultivation of cinnamon in this country. There are large stretches of land, very similar to that where the Anjarakandy plantation is situated, available for developing large-scale plantations in the Malabar coast and making India self-sufficient in this important spice.

Climate, soil and cultural practices.—The climate of the tract where cinnamon is cultivated in this State is very humid being only about nine miles from the coast, and almost at sea-level, with salt water in the river just below the plantation during summer. The soil is comparatively poor, lateritic, rather open in texture and with a fair admixture of sand. The general opinion is that the best soil for cinnamon is a sandy, loose soil at a low elevation. Prolonged spells of dry weather is not considered suitable for its successful culture.

Varietal introduction and trial.—The variety that is grown at Anjarakandy is reported to have been obtained from Secheylles. In Ceylon different varieties are known, the best being ' *Pat* ' or ' *Ma-Pat Kurundu* '.

At the Research Stations in Burliar and Taliparamba cinnamon is being grown mainly for seed material for distribution to the public.

Agronomic trials and experiments.—Cinnamon is propagated from seed in Ceylon and Malabar. Propagation is also done

by softwood cuttings or occasionally layering. Trials at Burliar showed that cuttings were very successful. Seeds without the fleshy pericarp but the seed coat in tact, collected from the base of the cinnamon trees, gave almost cent per cent. germination at Taliparamba. The seeds, however, had not much chance for spoilage due to the fact that the fruits had ripened and shed only a few days prior to collecting and sowing. Trials at transplanting self-sown seedlings from underneath the old trees to nursery beds in July 1945 also proved very successful.

Harvesting.—Under favourable conditions, the cinnamon seedlings attain a height of about five to six feet within two or three years after transplanting, when the first cutting is made. In Anjarakandy the growth is slow and it takes about four years for the first cutting. The season for cutting depends upon the rains, and is generally done in May-June and again in October-November.

The yield of the bark varies according to the climatic conditions as well as the age of the plants. It diminishes to about 50 per cent. after the first ten years. The average yield is about 50–100 lb. of quill per acre.

The research work has been limited to some trials on the propagation at Agricultural Research Station, Taliparamba and Fruit Research Station, Burliar. Large numbers of seedlings of this spice have been raised at Taliparamba and Burliar and distributed to different parts of the State.

Future work.—The cultivation of this valuable plant should be expanded on a plantation scale in places where it can be grown successfully and a good quality bark obtained as in Malabar. The demand is largely met by imports at present and there is scope to make the country self-sufficient in this spice.

ASAFOETIDA OR HING (*Ferula alliacia and Ferula fœtida*).

The plant from the roots of which asafœtida or Hing is obtained is not cultivated anywhere in India except in Kashmir. It is grown mainly in Iran, Afghanistan and the North-West Province of Pakistan. With a view to grow this plant in South India, seeds were obtained in 1934 from North-West Frontier Province and again in 1941 from Kashmir. Attempts to raise the seedlings were carried out at Kallar, Coonoor, Coimbatore, Nandyal and Hagari, but the seeds failed to germinate. It is doubtful if this plant will grow under the South Indian conditions, as it requires very cold conditions for its satisfactory growth.

CURRY LEAF (*Murraya Kœnigii*).

The most commonly used leaf spice in India is the curry leaf. It is used with various culinary preparations to impart a pleasant flavour. The tree or bush is found to grow very well in all parts of this State, except in the higher elevations (3,000 feet above

mean sea level). The plant is propagated from seed. They can be raised from root suckers also. The fully ripe seeds are sown and seedlings raised or self-sown seedlings which are common in compounds with grown up trees, are carefully lifted and planted near a water channel or any other place where it will be moist even during dry season. It grows fairly well even without watering or irrigation. The plant responds to manuring, and within about three to four years will attain a sufficient size for collecting leaves. It is not advisable to pluck the leaves from young plants, as it retards the growth of the plant. Once the tree has grown to a height of about five to six feet, leaf will become available for collection at intervals of about three months in good situations. While collecting the leaf, it is not advisable to cut or break small branches. Only the leaves from the lower portions of the smaller branches should be removed. Otherwise, the young tree will have a premature death. The fresh leaves are marketed, as the dry leaf is useless. The leaves contain an essential oil which can be distilled. In India the leaf is considered to have carminative properties.

Seedlings of this plant are being propagated in various Agricultural Research Stations and distributed to the public.

MINT (*Mentha virides*) AND PEPPERMINT (*Mentha piperata*).

Mint is a commonly used spice in most Indian household for flavouring various culinary preparations and in making *chutneys* with other ingredients.

There are two varieties of mint, one the common mint (*Mentha virides*) which grows both in the higher elevations as well as in the plains, and the other, peppermint (*Mentha piperata*) which grows well only in the higher elevations. Both require a friable rich soil and irrigation during dry weather for their successful culture. The plants are propagated from cuttings or by dividing the clumps into slips with roots. In dry situations the plants will die out after flowering, if they are not watered during dry weather. But if the plants are watered, even if the shoots flower and die out, new shoots will develop from underground and the plant will continue to grow as a clump. The plant grows very vigorously and within about three months of planting will be ready for cutting. If the plants are kept watered, cuttings can be taken at intervals of about three months. Peppermint has been introduced at Government Botanical Gardens, Ootacamund and large numbers of plants have been multiplied and are being distributed. There is considerable scope for large-scale cultivation of the peppermint in this country for extracting the oil for which there is a great demand and our requirements are at present met by imports from other countries. The oil of peppermint is very valuable as one of the most important source of menthol. The oil is obtained by distilling the leaves and the tender stems with steam.

Clove (*Eugenia caryophyllata*).

Production and importance.—In Madras State, clove is cultivated around Courtallam in Tirunelveli district and Burliar on the eastern slopes of the Nilgiris. In Courtallam there are about 1,500 trees and in Burliar about 500 trees and the average annual production can be estimated at 10,000 lb. of dried cloves.

In India, clove is growing in some estates in Travancore. The main clove producing countries of the world are Zanzibar, Pemba, Moluccas, Sumatra, Malaya, Seychelles, Mauritius, Bourbon, Madagascar and West Indies.

Clove is in popular demand in India for spicing foodstuffs. The production in India being small the requirements of the country are mainly met by imports from Zanzibar. There is, however, considerable scope for extending the cultivation of this spice in various parts of Madras. In the lower elevations of the Western and Eastern Ghats and the West Coast some extension is possible. Want of irrigation facilities, however, may prove a limiting factor for its large-scale extension in these tracts.

Climate, soil and cultural practices.—Clove is found to grow in India in a humid, tropical climate from almost sea-level to an elevation of about 3,000 feet and with an annual rainfall of about 60 to 120 inches, and from a distance of few miles to about 100 miles from the sea. According to Redgrove "if clove is grown in too moist a climate, it will not flower. Dry periods alternately with moist ones, as in Zanzibar and Pemba, are essential".

In India, where this spice is grown the soil is clayey mixed with gravel and a fair quantity of humus. Ridley is of the opinion that sandy soil is unsuitable and that waterlogged soil is still worse. In India, the plant thrives only if it is periodically irrigated during the drought season, at least till the plants are some years old.

In Zanzibar the seedlings are retained in the nursery beds for about a year when they are lifted and transplanted in the field. In Sumatra seedlings of about four feet in height only are transplanted. In Amboyna self-sown seedlings are planted, as it is believed that such seedlings produce more fruitful trees than nursery raised ones. The experience in Madras is that seedlings which are only about nine to twelve inches in height and not established in seedling baskets or pots, suffer considerable casualties when transplanted to the field, in spite of careful attention. Therefore to avoid failures in the field, seedlings which are about 18 to 24 inches in height and which have started branching and which have been previously established in baskets or pots are to be transplanted.

The planting is done during the monsoon season and the spacing is 25 to 30 feet. Later, if sufficient rains are received no watering or irrigation is given; otherwise it is either pot

watered or irrigated regularly during dry weather according to the facilities available. In Zanzibar the seedlings are watered till they have established and started growing. In Courtallam and Burliar irrigating the young plants and grown up trees is common, but some of the old trees are found to be growing well without any irrigation.

Mulching the young as well as the old trees with leaves or grass, particularly during the summer months is beneficial. This is a common practice in Zanzibar. In Burliar Fruit Research Station also this practice has been found to be beneficial.

In India irrigation during dry weather appears to be necessary, at least in the early stages for its successful culture.

Varietal introduction and trials.—There is only one variety cultivated in India. The area under the crop should be increased by inducing cultivators to grow it in localities where it has already been found to grow well, and in other localities which are found suitable hereafter.

Agronomic trials and experiments.—Some preliminary investigations on propagation methods have been carried out since 1939–40 at the Fruit Research Station, Burliar. A trial on the sowing of the seeds by different methods, namely, with and without the pulpy seed coat and with the radicle upwards and downwards indicated that there is no difference in germination between sowing naked seeds and seeds with the seed coat, and that the seeds should be sown with the radicle pointing downwards for better germination.

Various trials on propagating clove by cutting, layering and grafting were carried out at Fruit Research Station, Burliar and these trials failed to give any positive results.

With a view to find out the suitability of this spice to different tracts, clove seedlings were planted in different stations in Madras. But the plant failed to establish in any of these stations.

Harvesting and yield.—The tree has been found to yield within eight to ten years from seed at Burliar, in Zanzibar in four to six years and in the Moluccas in six to eight years. The spice is the unopened flower bud produced on the terminal shoots of the twigs. The buds are collected when they are dull red in colour. It is necessary to pick the buds before they open out, as otherwise the value of the spice is lost. The buds are collected as they become ready and not all in one stage.

In Burliar, the crop is generally ready for harvest from February to May. In Courtallam the usual harvest season is about June. In Burliar in some years two crops have been obtained, one in February and another in September. In Zanzibar, the crop is generally ready for harvest from August to December, and in Malaya from November to January. In Moluccas two crops are obtained one in July and the other in December.

The yield has been found to vary considerably from year to year. Some trees do not bear at all for one or two years in Burliar as well as in Courtallam. The average yield at Burliar was about 5 lb. of dry clove per year per tree, though one tree might record as much as 20 lb. in certain years. The average annual yeild in Zanzibar for fully bearing trees is reported to be about 100 lb., in Amboyana, 5 lb., in Sumatra, 6 to 7 lb., in Malaya, 5 lb. and in Moluccas, 4½ lb. In Courtallam and Burliar areas, trees over 75 years of age are found to give satisfactory crops, though some of the branches have started drying.

Part played by research centres or stations for improving the crop.—The only Research Station in this State where clove is being grown is at Burliar. In addition to carrying out certain investigations on propagation methods on clove by cutting, layering and grafting and budding, this station has been raising large numbers of clove seedlings for the past nearly 75 years and distributing to different parts of India. Various research stations in the State have been trying to grow this spice to find out its suitability for cultivation in the different tracts.

Future work.—Further experiments on vegetative propagation of the spice have to be carried out so that a shorter statured and quicker yielding plant can be made available. Large numbers of well grown seedlings should be distributed in areas where this spice will grow.

VANILLA (*Vanilla planifolia*).

In Madras, Vanilla is found to grow very well in Wynad and fairly satisfactorily in Burliar on the eastern slopes of the Nilgiris. In Burliar there are only a few vines growing but in Wynad, there is a plantation nearly one acre in extent owned by a firm. It is reported that vanilla is growing very well in Coorg and in the hilly tracts of Travancore in some of the coffee and tea plantations.

Large quantities of Vanilla pods, vanilla essence and synthetic vanillin used to be imported into India. Recent import restrictions of the Government of India have considerably restricted the import of these articles and there is some scarcity for these particularly for Vanilla pods. There are large areas suitable for its cultivation in Madras and other parts of India and therefore there is scope for extending the cultivation of this spice on a large scale so that the import of the pods particularly can be completely stopped.

The countries where Vanilla is being grown on an extensive scale are Mexico, Tahiti, Madagascar, Secheylles, Reunion and Mauritius.

In India, vanilla requires a humid, tropical climate with an elevation of about 2,000 to 4,000 feet above mean sea-level and an annual rainfall of about 100 inches. It comes up very well in Wynad in clayey loam rich in humus with good drainage. In

other countries light soil with plenty of humus and very good drainage are considered essential for its satisfactory growth.

Vanilla requires medium shade for its satisfactory growth and as it is a climber it requires some low branching tree as a standard. In Wynad, it is being grown under the shade of silver oak and allowed to climb on a small tree known as '*Arali*'. It is also being trained to Anatto, Bauhinia, etc. Cashewnut is reported to be an excellent standard for this vine, as it is low branching and gives shade to the vine in addition to adding a large amount of humus and mulch near the vine.

In Wynad, a site where there is light to medium natural shade and rich soil with plenty of humus, is selected and the standard for Vanilla to climb upon established at a distance of about six feet. Propagation is from cuttings.

The vines start flowering three years after planting. The flowers have to be artificially fertilised to set fruit. This is done by taking the pollen from one flower and putting on the stigma of another. The fruits take about ten to twelve months to mature in Wynad.

The fruits are collected when the tip starts yellowing. The fruits grown in Wynad are about eight to nine inches in length and each vine is found to produce about 100 pods.

The pods are cured and it takes about two weeks for the curing to be completed. Only when the pods are cured, they develop the flavour.

Plants of vanilla are being propagated at the Fruit Research Station, Burliar, and distributed to the public.

CHILLIES (*Capsicum annum*).

Production and importance.—Chillies was introduced into India by the Portuguese about the seventeenth century and has become so acclimatised to Indian conditions that it has come to be thought of as indigenous to the country. As a condiment, it has become indispensable in every Indian home. Madras had the largest area in India with 336,000 acres in 1948–49 and a production of 143,700 tons. Guntur accounted for the largest area (76,900 acres) and next Kurnool (35,740 acres), while the districts of Ramanathapuram and Tirunelveli were also important. The crop figures both in the import and export trade of Madras.

Climate and soil.—The crop is grown rainfed in Guntur and Circars, and as an irrigated crop in the southern districts. It is highly susceptible to crop failures and attack by thrips. A deterioration in the crop was noted from 1925 onwards due to thrips (*scortothrips dorsatus*) attack, consequent on the large extension of the groundnut crop which brought the pest. The efforts of the department have, therefore, been largely devoted to control against this pest and introduction of varieties resistant thereto.

Varietal trials.—There are several trade types as the orange type, the thin long fruit, the medium type, and the short conical type. Control measures against thrips showed that tobacco dust applied three or four times minimised the damage, but a radical control measure was not possible on account of the capacity of the thrips to multiply rapidly through alternate hosts especially groundnuts, throughout the year. The results suggested the necessity of breeding thrip-resistant varieties. This work was started in the Guntur Agricultural Station from the year 1931.

Investigation showed that the insect has a short life cycle of about a fortnight, which facilitated rapid multiplication in the dry period of transplantation, the damage being most severe in January. Oridinary studies on the botany of the crop showed that flowers are both self and cross pollinated, the extent of natural crossing being 7 per cent. The pollen loses viability and the stigma becomes non-receptive in 24 hours. Comparative studies of varieties from Madras and Northern India showed that the latter were more resistant to thrips under Guntur conditions. A number of ecotypes were therefore selected from a pusa type (*Pusa* 46) and the best of them was 398, subsequently named G-1. This gave an increased yield of 30 per cent. over local Guntur type, but proved to be at best tolerant but not resistant to thrips attack. G-1 was first distributed in 1937–38 and has spread over 70 per cent. of the area in Guntur district. A later selection, 1402 giving about 40 per cent. increased yield over G-1 is now under multiplication.

Hybridization.—A State-wide survey of chillies in Madras was also undertaken. It was found that varieties with hairs on leaves and stalk were slow in succumbing to thrips attack. Attempts on crossing chillies to improve colour and pungency in G-1 did not give any improvement. The breeding work was intensified in 1949–50 under a joint scheme financed by the Indian Council of Agricultural Research and the Madras Government. Results showed that selections from *Kendrapura Subara, Balasore* (Orissa) and from Ceylon (No. 2150) gave 49 to 60 per cent more yield than G-1 due to greater prolixity and capacity to ward off thrips attack to a late stage.

A simple technique for emasculating chillies has been perfected at the Guntur Agricultural Research Station, disposing of the need for elaborate apparatus. This takes advantage of the epipetallous condition and staminal attachment.

Agronomic experiment.—Experiments showed that a spacing of six to eight inches between holes and planting singles in lines 22 inches apart gave an increased yield of 40 to 45 per cent over the method of bunch planting with 22 inches spacing both ways. Close spacing enabled the crop to mature earlier, well in advance of January, the period of maximum damage from thrips.

Work of the research stations and the future.—The main difficulty with the chillie crop is its frequent failure due to thrips attack. Work by the Government Entomologist has shown that this can be reduced by tobacco dusting, but for eradicating the damage, evolution of pest-resistant types better than G-1 is necessary. If the damage due to thrips can be got over, the importance of the crop in internal and export trade will be considerably increased.

PEPPER (*Piper nigrum, L*).

Production and importance.—Pepper occupies an area of about 103,700 acres in Madras and the average annual production was about 9,700 tons. Almost the entire area in this State is in the districts of Malabar and South Kanara, and Malabar accounts for over 90 per cent of the total.

India had held a prominent place in the world pepper market from very early times till the beginning of the 19th century, when keen competition from Malaya and East Indies (Indonesia) started, and India slowly lost her place as the world's main pepper supplier. While production in the South-east Asian and other countries increased mainly due to efficient plantation practices and organization, the production and export in India slowly came down as years passed. During the years of slump from 1930 to 1939 when the pepper price went down most of the plantations were almost completely neglected, and even the little attention given to the crop was almost stopped. However, the general increase in commodity prices during World War II and subsequently, and particularly the ravages caused to pepper plantations in the South-east Asian countries which were the world's main suppliers before World War II, the status of the pepper industry in our country revived greatly from about 1944. Prices started rising slowly from 1940 onwards, and in 1948–49 stood at Rs. 6 per lb. exceeding the peak price ever obtained before, namely, a rupee a lb. in 1927. On account of this greatly increased price, in spite of the devaluation of the rupee, India has been earning a considerable amount of dollar exchange from export to the United States of America. Therefore, pepper has a very important place in our country's dollar economy.

Climate, soil and cultural practices.—Pepper is a plant of the humid tropics requiring high humidity, warmth and an annual rainfall of about 100 inches or more for successful culture. On the west coast of India it is found to grow and crop well from almost sea level to an elevation of about 4,000 feet on the western slopes of the western ghats from Cape Comorin to the northern borders of North Kanara.

The soil best suited for pepper is a rich friable loam with a high humus content and good drainage, but it thrives well even in comparatively poor soils with a considerable admixture of gravel

and a comparatively low humus content, as in the coastal areas of Chirakkal and Kottayam taluks of Malabar district, provided there is proper attention and good drainage. On the West Coast, cultivation on a very extensive scale is restricted to the interior, on and just below the Western Ghats. Land previously cultivated for a number of years to different seasonal crops is almost never utilized for opening plantations in this region.

In India, pepper is invariably grown only to live tree standards. The standard most preferred for starting new plantations is *Erythrina indica* (*Mullu Murikku or Kalyana Murikku*). The other standards generally used are *Garuga pinnata* (*Karayam*) and *Spondias mangifera* (*Ambazam*) the stems of which strike root easily.

Pepper is generally propagated from cuttings. It can however be raised from seed also. In Malabar and South Kanara it is considered best to take cuttings from the long shoots which develop from the base of the old vines, as these possess small roots and therefore establish quickly when inserted in the ground. If sufficient cuttings from the basal shoots are not available, next preference is given to the long shoots hanging down from the top of the vine. These shoots, as they seldom have small roots developed at their nodes, do not establish so well as the cuttings from the basal shoots. Cuttings from the short branches on the vine are never used for planting or raising nursery in India or anywhere else, as they seldom develop shoots which grow up the tree as climbers and their powers of producing new roots and shoots are very limited. No experimental evidence on this point is available in our country.

On the West Coast, unrooted cuttings are generally planted. But planting layered or rooted cuttings has become common during recent years by the more enlightened growers, in spite of the extra cost involved. In Sirsi, in North Kanara, rooted cuttings are preferred to unrooted cuttings. In Ceylon and other countries rooted and unrooted cuttings are planted. No experimental data on the superiority of rooted cuttings over unrooted cuttings for planting are available. However, from experience, the layered or rooted cuttings are found to establish with considerably less casualties and have a much better start than unrooted cuttings. Another advantage of layered or rooted cuttings is that they can be planted even slightly later in the season than unrooted cuttings, which is risky with the later, particularly if the north-east monsoon fails.

Pepper is planted invariably on the eastern side and sometimes on the north-eastern side of the standard, so that the trunk of the standard will give protection to the base of the vine from the scorching effect of the afternoon sun during summer, and it is never planted on any other side of the standard by careful

growers. Cuttings are planted in the period from the last week of June to the end of the first week of July when incessant showers are received. Generally, the vines are allowed to climb up the standards to a height of about twenty feet. But when trained to the trees like mango or jack, it is common to allow these to grow up to about 25 or 30 feet even. No manuring is ever practised on the West Coast, except in North Kanara where the vines trained to arecanut get the benefit of the manure applied to the latter. In Malaya, Java and other countries heavy application of cattle manure, compost, ash, burnt earth and fish manure is systematically practised once or even twice every year, but no chemical manures are applied. The higher pepper yield in these countries over India may be due to the fact that the vines are heavily manured and properly looked after in those countries, in addition to their better climatic conditions.

Pepper starts bearing a small crop in the third year of planting, but it is only from the fourth year, by which time the vines would have branched well and almost completely covered the major portion of the trunk of the standard that a sizeable crop is obtained. The vines come into full bearing from about the seventh year and continue to give satisfactory crop for about another ten years.

Varietal introductions and trials.—In Malabar, four varieties are generally cultivated. These are *Balamkotta*, *Kalluvalli*, *Cherukodi* and *Uthirankotta*. Accurate descriptions of these varieties have not been recorded. The difference between these four varieties is very marked in the matter of the length of the 'spike', the size of the individual berries, the compactness of packing of the berries on the 'spike', the density of the berries and the percentage of abortive berries (very small sized, under-developed berries). The difference between the foliage, length of internodes, etc., of different varieties is not so marked, varying as it does between vines of the same variety according to the vigour of the individual vines. There is also fairly marked variation in the flowering and maturing period of the different varieties. *Uthirankotta* flowers and matures the crop very much earlier than the others. *Kalluvalli* and *Cherukodi* are mid-season varieties, while *Balamkotta* matures the crop last. The spikes of *Balamkotta* are the longest and that of *Cherukodi* the shortest, that of *Kalluvalli* slightly shorter than that of *Balamkotta* and that of *Uthirankotta* very slightly smaller than that of *Kalluvalli*. The spikes of *Cherukodi* are very closely packed with berries, and that of *Kalluvalli* closely packed with slight gaps in-between clusters of berries. *Balamkotta* is not so closely packed as the two mentioned above, but the berries are evenly placed throughout the entire length of the spike. In *Uthirankotta*, the berries are very few and the greater portion of the spike is devoid of berries. In addition, these few berries start dropping off even before they start ripening. The size of the berries is biggest in *Uthirankotta* and *Balamkotta* and smallest in

Cherukodi. Some difference in the size of berries of the same varieties grown in different tracts has been noticed. The berries of *Balamkotta* grown in Wynad are markedly larger than that of the same variety grown in the other regions of Malabar. A difference in the amount of abortive berries (small sized, under-developed berries) on the ' spikes ' is also found between varieties. In the more recent plantations of Malabar, only *Balamkotta* and *Kalluvalli* are generally planted and *Uthirankotta* is rigorously excluded on account of its poor yield. In the lower elevations of Malabar, *Kalluvalli* is favoured. But in Wynad, the variety most favoured is Bolamkota on account of the fact that the spikes mature late in February-March after the coffee harvest is over.

Some wild forms of pepper are found in the hilly regions of the Western Ghats. The berries of these are small sized and they are only very slightly pungent though they have a flavour of pepper. These have no economic value at present. Being a very hardy type, it is possible that the wild varieties may serve as rootstock for grafting pepper and also for evolving new useful types by hybridization.

Experimental work on evolving new types by hybridization has not been attempted so far in this country. Recently varieties from Travancore, Wynaad and the plains have been planted at the Agricultural Research Station, Taliparamba, for preliminary comparative trials on yield and resistance or susceptibility to ' Hollow Berry ' (*pollu*) disease. The data recorded so far have shown that the Travancore varieties, *Chomala*, *Kottanadan*, *Munda*, *Tulakodi*, *Mundi* and *Karuvalli* are superior to the local varieties including those obtained from Coorg and Wynad in the matter of vigour and yield, though these have not been found to be any better than the local varieties in the matter of ' *pollu* ' susceptibility.

A scheme financed partly by the Indian Council of Agricultural Research and partly by the State Government for research on pepper for improving the industry in all its aspects has recently been sanctioned and the work in the scheme is being initiated.

Agronomic trials and experiments.—No elaborate and large-scale experiments on the agronomic aspect of pepper cultivation have been carried out so far. But a small-scale trial to determine the best among the most commonly used three tree standards was started at the Agricultural Research Station, Taliparamba, in 1943 and is in progress. Some elaborate spraying trials on ' *pollu* ' disease control was carried out in 1926 and some preliminary trials on manuring of pepper was carried out from 1928–1940. All these trials were at the Agricultural Research Station, Taliparamba.

Trial of different standards.—A small-scale trial to determine the most suitable standard for growing pepper was started in 1943

with three kinds of standards, namely, *Erythrina indica*, *Garuga pinnata* and *Spondias mangifera*. The data recorded so far have definitely shown that *Erythrina indica* is far superior to both *Garuga pinnata* and *Spondias mangifera*. While 98 per cent. of the Erythrina standards planted established only 65 per cent. of *Spondias* and 54 per cent. of *Garuga* standards have done so, Further, 90 per cent. of the pepper cuttings planted to *Erythrina* has established, as compared to only 65 per cent. of those planted to *Spondias* and *Garuga* respectively. Not only have the vines grown to *Erythrina* made very much better growth than those planted to *Garuga* and *Spondias*, but they have also recorded appreciably higher yields.

Manurial trials.—The effect of application of lime at ½ lb. per vine in alternate years to pepper vines and also the effect of application of combinations of different chemical manures to both the limed and unlimed vines was tested from 1928 to 1940. Though the data recorded showed that the limed vines gave higher yield than the unlimed vines and that nitrogenous and phosphatic manures increased the yield of the vines, further trials are necessary.

Harvesting and yield.—Pepper commences producing spikes generaly in June on the West Coast after some heavy showers are received. If heavy rains are received in April or May after a long spell of dry weather, it will induce the vines to come into flush and spike soon afterwards, and this will affect the yield adversely. Large-scale flushing and spike formation on the entire vine within a few days in June-July and rains at the time when the flowers have started opening and till the fruits have set, are believed to be favourable conditions for good yields. *Uthirankotta* will start flushing with a considerably lesser amount of rainfall received than that required for the variety *Balamkotta*. In the south-east Asian countries and Ceylon the vines flush and flower twice a year. This habit of two crops of blossom is not a varietal character but is dependent on seasonal factors. In Wynad, the flushing is slightly later than in the other parts of Malabar. Pepper produces 'spikes' on the new shoots from the lateral branches of the previous year.

The pepper is ready for harvest on the West Coast from December and the harvest continues till about February. At higher elevations in Wynad, the harvest begins from about the end of January and continues till the beginning of April. In North Kanara the harvest begins in March (Sahasrabudde).

The yield of pepper is very variable on the West Coast as it is mainly dependent on the varieties grown, seasonal factors and the incidence or absence of pests and diseases. The yield figures at Taliparamaba Agricultural Research Station for some years will give a clear idea of such variations in yield.

—	1932–33.	1933–34.	1934–35.	1935–36.	1936–37.	1937–38.	1938–39.	1939–40.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LB.
Yield of green pepper per acre of cultivated area (giving 2 diggings, lopping branches and tying).	386	8	972	121	509	143	142	1,820
Yield of pepper per acre of uncultivated area. (tying the vines only).	36	8	274	89	116	9	40	285

Obviously inter-cultivation has been very useful. In regular plantations in the hilly tracts the yield generally varies from a few pounds per acre in certain years to about 1,200 lb. of dried pepper rarely. The average annual yield per acre, however, can be estimated at about 200 lb. of cured pepper per acre.

The average yield per year is reported to be 2,400 lb. per acre in Malaya, 2,240 lb. in Ceylon, 1,200 lb. in Sumatra and 1,300 lb. in Cambodia. From the foregoing, it will be found that the yield is the lowest in India compared to all the other more important pepper growing countries in the world.

On the West Coast the vines generally will be in good vigour till about the fifteenth year when most vines start declining. But some vines continuing to grow vigorously for about 40 to 50 years and giving very heavy crops is not uncommon. In most plantations no inter-culture or attention is given after about twenty years. In Wynad, the vines, if not affected by 'Pepperwilt' continue to bear heavy crops for nearly thirty years.

The part played by research centres and research stations in improving the crop.—The main research work carried out in this State on this crop so far was at the Agricultural Research Station, Taliparamba, Malabar. The early investigations on the control of the 'Hollow Berry' disease were carried out at Taliparamba from 1926 by the staff of the Government Mycologist and the Government Entomologist. The result of these trials have already been mentioned in the paragraph on pests and diseases.

Some preliminary agronomic and manurial investigations for improving pepper cultivation have been carried out and are also in progress at the Agricultural Research Station, Taliparamba, and the results achieved have already been mentioned. Realizing the importance of improving this crop, a pepper specialist, to deal exclusively with this crop, has recently been appointed, and a scheme, prepared by the Government Mycologist, for research on pepper with special reference to the control of the two important diseases, partly financed by the Indian Council of Agricultural Research and partly by the State Government has been sanctioned.

As has been done in other major crops, like rice, cotton, etc., the evolution of new strains and the study of agronomic practices to improve quality and quantity will be the main features of work of the Pepper Specialist in the future.

CORIANDER (*Coriandrum sativum*).

Production and importance.—The area under coriander in Madras is about 110,000 acres. It is grown on an extensive scale in the districts of Tiruchirappalli, Tirunelveli, Bellary, Anantapur and Guntur, and on a fairly large scale in all districts of this State, except Visakhapatnam, Tanjore, Malabar, South Kanara and the Nilgiris.

Corander is an important condiment in Indian culinary preparations. It gives a fairly good return to the cultivator. Though the crop is grown mainly for home consumption, there is a substantial export also of this condiment from India, particularly from Tuticorin in Malaya and Ceylon.

Climate, soil and cultural practices.—In Madras, coriander thrives best in the hot and dry regions like the Rayalaseema and the Circars and the central and southern districts. The crop, however, grows even under cold condition also, as seen from the fact that it is growing in European and North African countries also. In this State, it is generally cultivated rainfed in the black cotton soil and rarely as an irrigated crop, either as a pure or a mixed crop.

Varietal introductions and trials.—Different varieties of coriander are not known in India. The Indian variety is reported to be more elongated in shape than the European types, which are spherical. The Russian variety is smaller in size than the produce of Morocco and India, but there is no difference in the quality (essential oil content) and size of fruits between the Indian and the Moroccan produce, though the latter has a more attractive colour. The Russian variety is superior to both the Moroccan and the Indian varieties as its essential oil content is almost double. Experiments carried out by the Government Agricultural Chemist at Coimbatore have revealed that the essential oil content and the other soluble constituents of coriander vary inversely to the size of the seed.

Some selection work on coriander to select high yielding types was carried out at the Agricultural Research Station, Koilpatti, and a selected type superior to the bulk is under comparative trial in the districts.

Agronomical trials and experiments.—Agronomical trials carried out at the Agricultural Research Station, Koilpatti, on raising coriander as a mixture with cotton from October to February indicated that coriander can be grown at a low seed rate mixed with cotton advantageously, without affecting the yield of the latter. Another series of trials on the effect of raising a mixed crop of coriander with cotton on the succeeding crop of Bajra indicated that the yield of Bajra following the mixed crop is reduced and that the yield of Bajra following a pure crop of coriander is more than that following a mixed crop.

Harvesting and yield.—The crops sown in October come for harvest by the middle of February. The bunches of fruits are cut and dried and the fruit separated from the stalk. The average yield is about 300 lb. per acre.

Preparation for the market.—There were severe complaints in 1933–34 that the Indian product was unclean and inferior to the Russian and Moroccan coriander available in Ceylon market. A detailed examination of the samples of Indian, Burmese, Russian and Moroccan coriander obtained from Ceylon market and a sample of coriander from Coimbatore market was, therefore, carried out by the Government Agricultural Chemist, Coimbatore, in 1934. The following extract from a communique issued by the Government of India after examination of the samples by the Government Agricultural Chemist will be of interest to the growers as well as exporters in India.

The analytical data revealed that the poor quality of Indian coriander as compared to Morocco and Russian samples was due to adulteration with dirt. In the words of the Government of India who issued a report on the analysis of the Government Agricultural Chemist—

"The main results are of general interest as they provide a striking example of Indian produce of intrinsically good quality losing ground by reason of adulteration of the clumsiest character.

It is obvious that with even reasonable attention to cleanliness, Indian coriander can easily hold its own and it is important that steps to this end should be taken for India cannot afford to lose any of its markets for these minor agricultural products which in the aggregate mean so much to the cultivator and market gardener."

Part played by research centres and stations for improving the crop.—The Agricultural Research Station, Koilpatti, has carried out selection work for isolating superior types and succeeded in selecting a superior type. Agronomical trials indicated that it was profitable to grow it as a mixed crop with cotton. The Agricultural Chemist has carried out detailed investigations on the quality of coriander of different origin.

Future work.—Further work for selecting high yielding types with greater essential oil content so that the Indian product can compete with the Russian product in foreign markets is necessary.

CARDAMOM (*Elettaria Cardamomum Maton*).

Production and importance.—The area under cardamom in the Madras State was about 16,000 acres with an annual production of approximately 400 tons. The crop is cultivated in the districts of Madurai, Tirunelveli, Ramanathapuram, Coimbatore, Salem, Malabar and the Nilgiris.

On account of its extensive use in the allopathic system of medicine and for extracting the essential oil it contains, cardamom is in great demand from foreign countries and is, therefore, largely exported from this country.

Climate, soil and cultural practices.—Cardomom requires special conditions of climate and soil for successful culture. In Madras it thrives best at elevations ranging from 2,500 feet to 4,500 feet above mean sea-level, in evergreen forests with a well distributed annual rainfall of over 80 inches. A rainfall ranging from 100 inches to 150 inches is considered optimum. As cardamom is a shade-loving plant, its successful culture is possible only in evergreen forests with heavy overhead shade throughout the year. A fine rich loamy soil with a well-developed mulch and a thick layer of humus is the best for the crop. The main limiting factor for its successful culture does not appear to be the mineral constituents of the soil, but the physical texture and the humus content.

Cardamom is propagated both vegetatively and from seed. The former method consists of uprooting a cardamom clump and separating out the ' bulbs '. Seed propagation is much more laborious than vegetative propagation. The cardamom seed does not remain viable for long. Hence, seed for sowing is collected only a few days prior to sowing. Germination starts four to six weeks after sowing and continues for about four months. When the seedlings have grown to a height of about six to twelve inches, they are lifted carefully from the seed beds and transplanted. The seedlings start yielding about three years after planting, while the ' bulbs ' start yielding about a year earlier. The first crop is a lean one, the second is fair and the third is a full crop.

Varietal introductions and trials and evolution of varieties.—Four prominent varieties of cardamom are met with in South India. These are ' *Malabar* ', ' *Mysore* ', ' *Ceylon* ' and *Munzerabad* '. Short descriptions of the above varieties and their important economic characters are given below :—

(1) ' *Malabar* ' is the most common variety, widely cultivated on the Travancore hills and south-western ghats. The plant is of medium size, neither so robust as the ' *Mysore* ' nor as stunted as the ' *Munzerabad* ', with the under-surface of the leaves softly hairy and velvety and the leaf stem green or whitish at the base and the pods round or slightly elongate. The panicles are prostrate or creeping and smaller than those of the ' *Mysore* ' and the plants less productive, though more drought resistant. It is more suitable to lower elevations.

(2) ' *Mysore* '.—The plants are more robust and vigorous than the ' *Malabar* ', the leaves larger and coarser with a darker green apearance, smooth on the under-surface and not soft and velvety. The panicles are longer than the ' *Malabar* ' and erect and more productive, and the pods elongated. This variety is more suited to higher elevations and withstands exposure and wind better.

(3) '*Ceylon*'.—The plant is more vigorous and robust than the '*Mysore*'. The leafy stem has a pink tinge deeply marked at the base and traceable up to the tip. The leaves are smooth and the panicles are erect and the pods elongate and loosely arranged in the panicle.

(4) '*Munzerabad*'.—The plants are more stunted than the '*Malabar*' but yield well. The panicles are prostrate and the pods round and arranged closely on them.

Besides the above four varieties, the research staff of the department has isolated a large number of different types which are the natural hybrids of the different main varieties, and they have been multiplied for comparative study of yield, resistance or susceptibility to pests and diseases and other economic characters. The following are the types selected so far:—

(1) Anamalai—erect.
(2) Anamalai—semi prostrate.
(3) Anamalai prostrate.
(4) Pattiveeranpatti.
(5) Bodinayakanur, III.
(6) Bodinayakanur, IV.
(7) Singampatti—indigenous.
(8) Singampatti—Ceylon.
(9) Munzerabad.
(10) Moonar—flexuous.
(11) Moonar—erect.
(12) Moonar—creeping.
(13) Coorg—indigenous.
(14) Coorg—Munzerabad.

Further selections also have been made from the original selections of Singampatti cardamoms, made by Messrs. Bombay Burma Trading Co., Ltd., and these are under comparative yield trials.

Hybridization work for evolving superior types from Singampatti types were initiated by the Cardamom Specialist at Singampatti and crosses between the undermentioned types have been effected:—

(1) Singampatti indigenous × Singampatti Ceylon.

(2) Panicle erect × Panicle prostrate.

(3) Leaves smooth × Leaves pubescent.

(4) Round pod × Long pod.

Agronomical trials and experiments.—Systematic research work in cardamom in this State was started only from 1944, when a scheme for scientific aid for the cardamom industry of South India, financed by the Indian Council of Agricultural Research and State Government on a 50:50 basis was sanctioned, with a Cardamom Specialist and the necessary staff. The results of the various experiments carried out are given below:—

(*a*) *Germinating medium and soil texture of seed bed.*—The optimum medium for proper germination and growth of the seedlings in the seed beds was investigated on the following treatments with black '*shola*' soil spread to a depth of one inch on the prepared nursery beds as control: (1) Black *shola* soil mixed with sand in the proportion of 4 : 1 by volume, (2) Black *shola* soil

mixed with leaf mould in the proportion of 4 : 1 by volume, (3) Black shola soil mixed with wood ash in the proportion of 4 : 1 by volume, (3) Black *shola* soil with well-rotten powdered cattle manure in the proportion of 4 :1 by volume.

The trial has showed that a mixture of black *shola* soil and powdered well-rotten cattle manure and black *shola* soil and ash in the proportion of 4 :1 are better media for nursery beds than leaf mould, sand or pure *shola* soil.

(*b*) *Effect on pre-treatment of seed.*—With a view to find the effect of pre-treatment of the seed before sowing on the germination and the final stand of seedlings, an experiment was conducted with four treatments, namely, steeping the seed for twelve hours (1) in cowdung slurry, (2) in tepid water (115° — 118° F.), (3) in cold water and (4) in Hortomone 'A' solution in water (0·3 per cent) and with untreated seed as control. There was, however, no significant difference in germination and final stand between the different treatments and the untreated seed.

(*c*) *Effect of scarification of seed with sand on germination.*—Shaking the seed with coarse sand and scratching the seed coat give quicker and higher percentage germination than the untreated seed.

(*d*) *Comparative merits of different mulch for seed-beds.*—Cardamom beds have to be mulched to produce warmth for germination, to retain the moisture in the bed and to prevent the ill-effect from drip of shade trees or *pandal*. Experimental results show that mulching is necessary and that grass serves as a better mulching material than dry leaf or jungle debris.

(*e*) *Shading method for nursery beds.*—Shade is generally provided to cardamom nurseries by three different methods, namely, (1) natural shade of forest trees, (2) non-rain-proof *pandal* and (3) rain-proof *pandal*. Experiments on the relative merits of the above three methods showed that shade provided by means of *pandal* gave better protection to the seedlings than the natural shade from the forest trees and that the extra cost of providing *pandal* was worth investing.

(*f*) *Effect of sun and light on germination.*—It has been repeatedly observed that the beds at the two ends of a long *pandal* registered better germination than the seed-beds in the middle. Experiments have indicated that it is more advantageous to have short beds with a short *pandal* than a long row of beds with a single long *pandal*.

(*g*) *Viability of cardamom seed.*—Cardamom seeds are usually sown soon after collection as it is popularly believed that they lose viability if kept too long. The sowing trials, conducted so far, indicated that sowing the seeds soon after collection is more advantageous than sowing after a lapse of 15 days and more.

Experiments are in progress to find out (i) the optimum season for sowing seed, (ii) the yield of different selections, (iii) the reasons for the difference in the tillering habits of individual clumps and (iv) the performance of plants in relation to the length of the mother rhizomes.

Harvesting and yield.—As cardamom flowers over an extended period, the harvesting extends over a number of months. The main harvest season for the '*Malabar*' and '*Coorg*' types in the northern tracts is from September to January, while that for the '*Mysore*' type in the central tracts is from October to April. In Singampatti area, the harvest commences from July-August and continues till the end of April. The harvesting from the same clumps is generally done once in 30 to 40 days. The crop starts giving full yield only from the fifth year of planting in seedling plantations or from the fourth year of planting in 'bulb' plantations. The yield per acre varies widely according to the type grown and the tract. The annual yield for big cardamom (*Mysore*) is 50 to 100 lb. and that for small cardamom (*Malabar*) 40 to 80 lb., while in Ceylon the yield from a plantation in full bearing is about 300 lb. per acre.

Preparation for the market.—The cardamom pods have to be cured before they are marketed. The object in curing is to produce a light straw coloured pod with no black or brown spots or other blemishes and with as little splits as possible. A certain proportion of splits, however, is unavoidable, as every harvest is bound to contain a percentage of over-ripe pods. The curing of cardamom during bright and dry weather is a simple matter as sun drying is the most efficient and cheapest method. Long exposure to the sun, in an attempt to dry the produce quickly however, results in a large percentage of split pods.

As the peak harvest season synchronises more or less with comparatively unsettled weather conditions, artificial drying methods are to be employed for drying a large quantity of the produce in a comparatively short time, so that the produce may not be spoilt. A simple drying contrivance has been designed at the Agricultural Research Station, Taliparamba, suitable for efficiently drying the produce in comparatively smaller estates. In very large estates with a considerable output a small forced draft dehydrating chamber may prove more efficient.

The kiln dried cardamom of the larger varieties (*Mysore*) is green in colour, but the smaller cardamoms (*Malabar*) dry a more yellowish green. The sun-dried cardamoms are lighter in colour. The proportion of dry produce to green pods varies from 20 to 25 per cent. The kiln-dried cardamom requires bleaching to suit certain markets and this is generally done by treating the produce with sulpher-dioxide.

After drying and bleaching, the pods are clipped by scissors to remove the extra stalk and the dried calyx, and then sorted

into splits and entire pods. The entire pods are sorted according to colour of the pods and again sorted into commercial classifications like 'shorts' and 'long shorts', and in addition 'bold' and 'medium' according to the plumpiness of the pods.

Future research in improving the crop.—A scheme for research for improving the cardamom industry of South India submitted by the Government Mycologist, and partly financed by the Indian Council of Agricultural Research and partly by the State Government was sanctioned for five years with effect from April 1944, in the first instance, and was subsequently extended for another three years. The main research work is being carried out in the estates of Bombay-Burmah Trading Co., Ltd., in Singampatti, by the Cardamom Specialist and research staff, working under the Government Mycologist. The work carried out by the cardamom research staff on the various aspects of cardamom improvement has been summarised already.

Future work.—The future work consists mainly in pursuing the investigations of the various problems already initiated, till ways and means are devised for controlling the major pests and diseases responsible for lowering the yield, and superior high yielding resistant types are evolved.

NUTMEG (*Myristica fragrans*) AND MACE.

Production and importance.—This spice is grown near Courtallam in Tirunelveli district and round about Burliar on the eastern slopes of the Nilgiris. A few trees are found growing in Anjarakandi, about nine miles from Cannanore. Outside Madras, it is reported to be growing well in Alwaye and near Trivandrum, near the coast and in a few estates in the interior of Travancore. The total number of trees under cultivation in Courtallam and Burliar area will not exceed about 500 and the total number of trees in the whole of India may be about 1,500. The total yield can be estimated at about eight tons of dry nutmeg. But the major portion of the crop is generally sold as green nutmeg.

The countries where nutmeg is cultivated on a large scale are Indonesia, West Indies and Malaya.

Climate, soil and cultural practices.—In Madras, nutmeg is found to thrive in a humid tropical climate in the south-western regions from sea level to an elevation of about 2,500 feet above mean sea level, a few miles from the sea to a distance of about a hundred miles away from the coast and with an average annual rainfall ranging from 60 inches to 120 inches. The regions where nutmeg used to be grown on a large scale were and still are on small islands.

The soil where this spice is being grown in this State is fairly clayey with a good proportion of gravel. It is said that the deeper the tinge of iron in the soil the better it is for the full development of the tree. In Malaya, the best trees are reported to be

in lateritic clay loam. In Indonesia and West Indies also, a clayey soil is considered best for nutmeg. But in Moluccas where it is grown the soil is a rich volcanic loam with a large proportion of humus. Nutmeg is considered to grow well even in comparatively poor soil, so long as it is not too sandy and it is not too wet or gets too dry.

The plant is propagated from seed. In foreign countries grafting is reported to have been successful, but the performance of grafted trees has not been considered satisfactory. Trials on grafting, layering and raising plants by cuttings have not proved successful at the Fruit Research Station, Burliar. Fully-matured seeds the husks of which have split are collected and after drying for a day are sown with the shell in nursery beds in an open site shaded by *pandals*. The seeds start germinating in four to six weeks. When the seedlings are about six months old, they are potted and allowed to grow in the pots for about a year before they are planted in their permanent sites in the field. Seedlings, if transplanted to the field when too small, less than one foot in height, do not establish satisfactorily. In Malaya, seedlings about 6 inches in height are planted. It is also customary to sow seeds directly in the pit in the field. The spacing required for the plants is 20 to 25 feet, according to the gradient and fertility of the soil. If the gradient is high or the land comparatively poor, the lesser spacing only is required. Nutmeg requires medium shade for its successful growth, and particularly so in the first few years. The trees at Burliar and Courtallam are found to be growing in fairly heavy shade. Therefore, only partial clearing of the site is to be done, removing all the bigger trees and retaining the smaller ones at intervals of about thirty feet. Bananas may be planted all round the pits a few months or one year in advance of planting, so that the former would have grown sufficiently to provide shade for the nutmeg plants. As the nutmeg plants grow bigger, the bananas can be thinned out and the trees left in the plot without felling would have grown sufficiently to provide the required shade. It is also a good idea to interplant nutmeg as a mixed crop with other established tree crops, which will shade the nutmeg plants. Planting in coffee or cardamom plantations may also be advantageous. The failure of nutmeg trees in Penang and Wellesley Province in Malaya is reported to have been due to want of shade.

In Burliar, a mulch of dry leaves is always given round the trees, increasing the extent as the tree grows bigger. Nutmeg has a lateral root system very near the surface and therefore digging the ground is avoided.

No manuring is done to the trees either in Burliar or Courtallam areas, and even though the trees in these areas are over about fifty to seventy years old they are still bearing heavy crops. In Malaya, the trees are manured with cattle manure, prawn dust and oil cakes. It is reported that heavy manuring of the trees in Penang was responsible for the death of the trees to a great extent.

The trees at Burliar consist of female trees with a more or less spreading habit and producing a large number of fruits and hermaphrodite trees which produce both male and female flowers and produce a very small number of fruits. These have a more upright habit than the female trees and produce a high percentage of double-nuts.

The male trees are generally cut down as soon as the sex of the tree is determined, i.e., when they start flowering leaving a few as pollinators. The only pruning that is done is to remove the dead branches and the excessive number of upright shoots that sometimes develop from the main trunk. The trees at Burliar and Courtallam have grown to a height of about 30 to 40 feet, and most of these trees are over fifty years old and some even over 75 years. The trees at Anjarakandi are about thirty feet in height and reported to be about hundred years old.

Varietal introductions and trials.—Different varieties of the cultivated nutmeg are not known in India. The West Indies nutmeg is reported to be different in shape to the Indonesian type being more elongated than the latter. The Indonesian nutmeg is considered superior to the West Indian. Variation in the shape and size of nuts produced by different trees is common in Burliar. Nutmeg was first introduced in Burliar and Courtallam over 80 years back, but its cultivation has spread only very little, even in these areas. A wild variety of nutmeg (*Myristica Malabarica*) is found growing wild on the Western Ghats.

Agronomic trials and experiments.—Investigations on the possibility of propagating plants by cutting, layering and grafting carried out at the Fruit Research Station, Burliar, failed to give any positive results. Though the early experience in other countries with grafted plants were not satisfactory, it may be worthwhile to investigate the possibilities of vegetative propagation of female trees of good performance and ensure the sex of the plants planted.

With a view to find out the possibility of growing nutmeg in different tracts in this State, planting trials of this spice have been made in a number of Research Stations in this State, but it failed to establish in all these stations. Recently, a large number of plants has been planted in Wynad to see if this spice would be suitable to this tract.

Harvesting and yield.—In Burliar, the trees start flowering, about twelve years after planting, while in Indonesia and Malaya, they do so from the eighth or ninth year. The fruits are ready for harvest in about six months from flowering. In Burliar, fruits become available for harvest almost throughout the year, but the main harvest is from June to October.

In Burliar, some trees gave about 4,000 nuts in certain years, but the average was about 1,250 nuts or about 20 lb. of dried nuts and about 2 lb. of mace. In Burliar about sixty nuts with shell weigh one pound.

Preparation for the market.—The mace is separated from the nut carefully without breaking and flattened out with the palm of the hand and the nuts and mace dried separately in the bright sun on mats. In Burliar, some difficulty is experienced for proper drying due to wet weather during the main harvest season, which is prejudicial and develops mould. After drying, nuts are preserved in airtight containers in a dry place. In Burliar, the dry nuts are not shelled but are kept without shelling. In foreign countries, nuts are dried over fire as well as in the sun, while the mace is dried in the sun, and the nuts are either shelled or preserved with the shell. The kernels are, however, always exported without the shell. In large-scale nutmeg producing countries, the nutmegs are shelled by machine. When the quantity is small, it is shelled by a mallet with the hand. The kernels are treated with lime before export to give them a good colour and to prevent insect damage.

Part played by research centres or stations in improving the crop.—The only research work carried out on this crop in this State is on the raising of plants by vegetative methods, so that female trees of good performance can be multiplied. The Fruit Research Station, Burliar, which is the only Research Station where this crop is being grown has been raising large numbers of seedlings of this spice and distributing it to different parts of India during the past few decades.

Trials have been carried out in many Research Stations to find out if this spice can be grown in these stations to assess the suitability of the different tracts for the crop. But this spice failed to establish in these stations.

Future work.—Further experiments on vegetative propagation of the plant have to be carried out, so that female trees can be propagated and planted and compared with seedlings. The possibility of grafting on nutmeg seedlings or on the wild nutmeg seeds has to be investigated.

Plantation Crops.

The chief plantation crops in South India are tea, coffee and rubber. These crops occupy 194,664 acres in Madras State and their cultivation is confined to the Malabar Coast and the region of the Western Ghats; the tracts are noted for their high rainfall and humid conditions. There are definite planting regions known as planting districts and they are Anamalais, Nilgiris, Nilgiris-Wynad, Shevroys, Madurai, Tirunelveli and Malabar. The estimated valuation of the planting industry in Madras State may be put down at 23 crores of rupees.

Tea.

The tea plant (*Camillia thea,* link) is said to be a native of Assam where it was found growing wild. Earliest attempts at

cultivation seem to have started in the year 1834 and then on, plantations increased on a large scale. The cultivation of tea in the Indian Union is limited to Assam in the north and to the regions of the Western Ghats extending from Coorg to Travancore in the south.

Cultivation of tea in South India is restricted to high altitudes and plantations between 2,500 and 6,000 feet above sea level. The rainfall in the tea districts ranges from about 60 inches to 150 inches and is sufficiently well distributed to help growth throughout the year. The temperature ranges between 55° and 90° F.

The total area under tea in Madras State was 81,000 acres in 1948–49 (Season and Crop Report, 1948–49). The Nilgiris had the largest area under tea (39,560 acres) followed by Coimbatore (24,720 acres) and Malabar (15,900 acres).

The average yield of tea varies widely dependant on the planting district. The production of tea in South India in 1949 was 99 million lb. and in the Madras State was 19 million lb.

Coffee.

Coffee is believed to have been brought to India and introduced in Mysore over two centuries ago by a Muslim pilgrim named Bababudan.

The first systematic plantation was established in 1836 near Chickmagalur in Mysore State. About the same time, plantations were started in the Shevaroys and Wynad in the Madras State. In the Nilgiris, plantations were organized only in 1846.

Several species of coffee are known but only two are popularly grown in South India, viz., *Coffea arabica* and *Coffea robusta*. *Coffea arabica* was the earliest introduction and produces a superior quality beverage, though susceptible to diseases. *Coffea, robusta* is a more recent introduction and is sturdier and more vigorous.

Coffee is generally cultivated in high altitudes ranging from about 2,500 feet to 5,000 feet, though *Coffea robusta* plantations are found to thrive even in lower elevations. The annual rainfall varies from 60 to 120 inches with a favourable temperature range of 55 to 90° F., though higher temperatures are not uncommon.

The total area under coffee in the Indian Union was 221,036 acres in 1948–49 and the area in the Madras State was 89,048 acres. The *Arabica* variety was planted over 61,853 acres and the *robusta* variety over an area of 27,195 acres. The annual

production of coffee in the Madras State and the Indian Union during the last three years were as follows :—

STATEMENT I.

Production in tons.

Year.	Madras State.			Indian Union.		
	Arabica.	Robusta.	Total.	Arabica.	Robusta.	Total.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1946–47 ..	3,038	1,180	4,218	12,100	3,256	15,350
1947–48 ..	1,981	2,784	4,765	6,976	8.830	15,800
1948–49 ..	5,817	1,445	7,262	18,150	3,560	21,750

(Annual Reports of the Indian Coffee Board, 1948–49).

Coffee production fluctuates widely from year to year depending upon seasonal conditions. The demand for coffee in the Indian Union is increasing with the increase in the habit of coffee drinking. Expansion in the coffee area is planned for.

Rubber.

(*a*) *Cultivation and importance.*—Rubber was planted in South India on an experimental scale by the end of the nineteenth century. The high prices at the time gave an impetus to the planting industry and by 1924 the area increased to 71,500 acres. In spite of violent fluctuations in the prices of raw rubber, more and more land was planted and by 1949, the area under rubber in the Indian Union was 167,820 acres. The Madras State has an area of only 27,780 acres, or one-sixth of the area in the Indian Union. Of this, Malabar accounted for about 90 per cent.

Hevea brasilensis thrives only in high rainfall regions with annual precipitations of between 100 to 150 inches. The plantations are distributed in low elevations. The production of rubber in the Indian Union was 15,587 tons in 1949, though a peak production of 17,174 tons was obtained in 1944. Separate production figures for Madras State are not available.

As most of the plantations were planted several years ago, the yields are relatively low, with an average acre yield of about 300 lb. Work towards increasing yields is now directed by introducing clones and budded material from high yielding trees. Plantations with such improved plant material are reported to yield around 1,000 lb. per acre.

Rubber is considered to be an important strategic raw material and therefore Government are protecting the industry by a price support programme within a closed economy through the Indian Rubber Board. The Indian supply of rubber is not sufficient to meet India's manufacturing industry. Rubber is, therefore, imported from neighbouring countries, particularly Ceylon. The imports in 1948 and 1949 were 4,630 tons and 2,836 tons, respectively.

(*b*) *Research.*—During the war, the acute shortage of rubber consequent on the falling of the Far East into enemy hands, led the Government of India to look for alternative sources of rubber. The first step was the investigation of the several rubber yielding plants existent in the State. Preliminary work was done at Coimbatore on the extraction of the latex from a number of plants and weeds listed below :—

(1) *Euphorbia tirucalli.*—The latex from this plant was not coagulated by acetic acid but by a mixture of tannic acid and hydrochloric acid. The results were not very satisfactory, further the rubber was high in resin content.

(2) *Ficus sp.*—Though the latex from this plant coagulated with acetic acid, the rubber was sticky.

(3) *Thevetia.*—The extraction of latex from this plant was difficult. Tapping as well as extraction was unsuccessful.

(4) *Lactuca.*—The extraction of latex from this plant was difficult by crushing.

(5) *White pagoda.*—Though profuse in latex, the rubber was sticky.

(6) *Poinsettia.*—The latex was coagulated by acetic acid. The rubber was elastic but became sticky on keeping.

(7) *Taraxacum kok-sagyaz*, the Russian rubber plant, was found to grow as a weed in the Nilgiris and Palni Hills in elevations ranging from 1,000 to 2,000 feet under humid conditions. It is easily propagated by planting root cuttings. Rubber is obtained from the dried roots and the yield was estimated at between 30 to 60 pounds per acre. Work on this plant was not, however, pursued.

Cryptostegia grandiflora was found to be the most suitable among the wild growing rubber yielding plants and further investigations were directed to this plant. This climbing shrub was introduced into this country from tropical Africa. It has become more or less naturalized. A botanical survey revealed extensive gregarious areas of this rubber vine in Kurnool and Tirunelveli districts and in a number of isolated patches in other districts.

Propagation trials showed that both vegetative and seed methods of propagation were successful. Propagation by seeds was recommended for quick multiplication. Seeds germinated readily and the seedlings were much more vigorous than cuttings. The seedlings with their penetrating tap roots withstood drought better. Transplanting seedlings from nurseries was found to be more desirable than direct sowing. Two months old seedlings established better than tender or over-aged seedlings. Under dry conditions broadcasting of seeds was successful in getting good stand.

The correct stage for the collection of the seeds from the pods was found to be when the pods turned brown. At this stage the seeds possessed 60 to 80 per cent viability. Germination trials with stored seeds showed that they improved in viability in the early

stages of storage. Viability was good even after 40 weeks' storing. Pre-treatment of the seeds by soaking them in water for four hours shortened the duration of germination and gave uniformity.

Histological studies of *Cryptostegia* indicated that the lacticiferous tubes were not easily distinguishable from the rest of the parenchymatous cells. In slightly older portions, however, they were larger than the parenchymatous cells and were therefore easily located. In longitudinal sections they appear as narrow, long tubes disposed parallel to one another. The latex tubes were found distributed throughout the plant, i.e., the root, stem, leaves and fruits and in all regions of soft tissue. In the stem, the latex tubes were located both in the region of pith and cortex. In the pith, they were more numerous and were located close to one another, while in the cortex, they were stray and scattered and occurred in the region of secondary cortex. In the leaves, they occur in the mesophyll and in pods, in the soft tissue of the mesocarp. The lacticiferous tissues were found present even at the very early stages of the seedlings and they appear to be formed at the time of differentiation of the tissues. At first, they were small but grew more rapidly than the surrounding parenchymatous cells and very soon became clearly differentiated from the rest of the tissues. They seem to elongate in length by the dissolution of the transverse walls of cells placed longitudinally in a line.

These studies revealed that the plants cannot be tapped by making incisions in the bark as in the case of rubber trees, since that method of tapping opens out only the tubes located at the periphery and not in the pith. Further, the latex tubes do not branch freely and connect other tubes. It was found essential to open every tube to obtain good results. The method adopted for obtaining latex was to cut the tips of vigorous growing shoots (whip shoots) and collect the latex that drips. The lacticiferous tissues were found to be rich in latex during the growing and elongation period of the shoots. Judicious pruning resulted in increased number of shoots being produced for tapping purposes. The quantity of latex obtained was the greatest during the morning hours up to 9 a.m., and this was considered to be the most suitable time for tapping. Each individual whip on an average yielded 0·45 c.c. of latex per tapping producing 0·06 grams of rubber.

Plants grown under irrigated conditions gave latex with 8 to 10 per cent of rubber. Tapping at intervals of three days induced more flow of latex than tapping daily or on alternative days. The pH of fresh latex as determined by hydroquinone and glass electrodes varied from 5·34 to 5·38. Coagulation of the latex occurred when the pH was between 4·5 and 4·8. This was effected by three per cent acetic acid in eight to twelve hours. Alcohol of 95 per cent strength could also be used as a coagulant but was not used commercially because of the large quantity required for coagulation.

In order to maintain the liquid state and prevent spontaneous coagulation which resulted during the collection of the latex, the addition of anticoagulant was found to be essential. Addition of a few drops of 0·3 to 0·5 per cent ammonia solution to vessels prior to the collection of latex was found to prevent latex coagulation.

Cryptostegia latex could be preserved for a considerable length of time with ammonia. It was possible to prepare sheet rubber out of the latex and the sheet rubber showed good keeping qualities. The rubber obtained was rich in rubber hydrocarbons and compared favourably with rubber from other rubber yielding plants. The yield of plug rubber depended largely on the season and the number of tappable shoots. Irrigation generally increased the yield of rubber and rubber from irrigated fields was superior in quality compared to the rubber from unirrigated plots and marked variations in quality were noticed. The leaf formed an important source of rubber containing from 3 to 6·6 per cent of rubber. A method involving fermentation of leaf material for the enrichment of the rubber content followed by chemical extraction was worked out for the recovery of raw rubber.

The plug rubber from *Cryptostegia* responded to all vulcanization tests for a number of mixes and the tensile and aging figures compared favourably with *Hevea* scrap rubber. Manufacturing test report from the Indian Rubber Manufacturers said that " it has attained sufficient mechanical strength to be of use for such articles as are not subject to severe mechanical stress and where a little imbedded dirt would not impair its quality in actual service. Rubber proofing of fabric can be attained with this rubber if suitable strainer of the nature of a fine sieve be used. Forcing the rubber solution through the sieve would remove dirt which should not be allowed to come in contact with proofed canvas. The periods of milling operations were considerably shortened due to the high resin content and breaking down of the rubber had to be done on the cold rollers."

Carbon dioxide was found to be the best preservative for *Cryptostegia* rubber in conformity with the practice of smoking Hevea rubber sheets, and smoking of *Cryptostegia* rubber was recommended to prevent mould and fungoid spot diseases. The two drawbacks in the way of *Cryptostegia* rubber becoming popular were (1) its high resin content and (2) the high cost of collection. The resin was found removable by solvent extraction.

Simultaneous with the technological studies, a scheme for the commercial production of rubber from *Cryptostegia grandiflora* was taken up in 1944 in Kurnool district. Both latex and plugs were collected daily for 15 days adopting the direct bleeding method and employing paid labour. The cost of collection worked out to Rs. 17–6–0 per pound. When plugs alone were collected daily, the cost per pound was Rs. 10–15–0. It was observed that the chief reason for the high cost was the thorny undergrowth in the

wild *Cryptostegia* plantation selected for tapping which impeded free movement of labour for collection. When the undergrowth was cleared, each labourer was able to tap nearly 3,000 shoots and collect a little more than two ounces of rubber every day. The cost of production was also reduced to Rs. 4 per pound. Owing to continued scarcity of rubber during the war period, the scheme of collection of latex was extended with a large staff of maistries trained in collection work. Arrangements were also made to purchase plug rubber offered for sale by villagers at Rs. 4 per pound. The results were not satisfactory and only 394 lb. of rubber could be collected. The proposal was, therefore, discontinued.

Cryptostegia grandiflora as green manure.—With a view to find out the potentialities of *Cryptostegia grandiflora* as green manure, field trials were conducted at Bannur, Coimbatore, Aduthurai, Pattukottai and Samalkota, comparing it with other green manures such as *Daincha, Sunnhemp, Pillipesara, Gliricidia* and *Sesbania speciosa*, in varying doses on paddy crop in presence and absence of 30 pounds P_2O_5 level. The trials did not give anywhere significantly higher yields compared to other green manure crop. Further essential characters of green manure plants, namely, quick growth and production of large quantities of foliage within a period of two to three months were found wanting. The nitrogen value of the rubber leaf (0·6 per cent on wet basis) was also not superior to other green manures. It was therefore found uneconomic to grow this vine for green manure purposes.

Scientific assistance to the planting industry.—The Planting Industry is now managing its scientific problems by itself. In earlier years, however, scientific assistance to the planting industry was rendered by the Government through the department for some time and later by financial aids.

In 1909, a Deputy Director of Agriculture, Planting Districts, was appointed. He visited as many of the individual estates as possible and devoted his attention to the solution of the more obvious problems, by means of lectures and propaganda. The use of green dressings and cover crops to improve soil fertility and prevent soil erosion, the introduction of a system of drainage, the use of lime to neutralize soil acidity and the adoption of rational manurial programmes instead of indiscriminate application of different kinds of manure for no particular reason, were some of the problems that were handled in this manner. Attention was also directed to the control of a large number of insect pests and diseases by the introduction of a system of spraying. A laboratory was started where it was possible to make a simple analysis of soils and manures.

In 1914, four experimental stations were established on a small scale to study the various problems which had arisen, manurial, cultural, etc. At the same time, two new strains of coffee had been evolved by plant breeding and selection methods with the help of coffee planters who had been working to this end for many

years but had not gained much success till they got scientific advice and help. These strains were widely planted and tried out under various conditions. A number of new problems were taken up, such as methods of tapping rubber, control of the mosquito blight and the Brown Blight of tea.

In 1919, with the transfer of the offices of the United Planters Association of South India to Coimbatore, the analytical work was taken up by the Government Agricultural Chemist. Many valuable investigations on the root diseases and the secondary leaf fall of rubber were conducted by the Government Mycologist during that time.

By 1921, the Planters generally had begun to realize the value of scientific advice. The rubber planters, therefore, made up their mind to get a specialist of their own and pay for him. A Rubber Mycologist with a Mycological Station was established at Mundakayam. He studied the problem of secondary leaf fall and showed how the disease could be controlled in a practical manner by spraying with Bourdeaux mixture. Afterwards the spraying of coffee was demonstrated against the coffee leaf disease. The objects of the coffee spraying experiments were (1) to find out to what extent leaf disease of coffee can be controlled by spraying, (2) to find the maximum strength of the solution for effectiveness and economy, (3) to test the efficacy of different kinds of adhesives when added to Bourdeaux mixture and (4) whether the health of the plant and the gain in crop compensate for the cost of the work. The spraying experiment brought out the fact that the leaf produced in the April-May flush was retained when sprayed, while the unsprayed lost practically all the leaf. On comparing the sprayed with the unsprayed control plots, it was found that there was not the same amount of ' die back ' in the sprayed plot, while the wood on the whole was stronger. Half per cent Bourdeaux mixture (2½—2½—50) with casein was found to be the most economical and efficient dose. Lime sulphur did not show significant results.

Though in 1909, there was a great deal of apathy among the planters and even a certain amount of opposition to the scheme of scientific assistance, in 1924 the United Planters Association of South India were not only very eager for advice but realized that they must have a much bigger and better equipped scientific department than they had then with more men working at special problems and with more facilities for study and opportunities for making themselves acquainted with the most modern developments in other countries.

To this end they put forward a scheme of development for a period of five years. Accepting the scheme, Government transferred the experimental planting stations to the United Planters Association of South India in April 1924. The Madras Government also agreed to contribute a sum of Rs. 28,000 annually for a period of five years in furtherance of the objects of the scheme.

The contribution was renewed for a further period of five years from 1929. In 1934, however, the Government reduced the annual contribution to Rs. 21,000 up to 1939, when it was further reduced to Rs. 12,000 per annum for a period of two years. The grant was enhanced in 1941 to Rs. 16,500 per annum for a period of three years from 1941–42 to 1943–44. The grant was discontinued from 1947.

THE CASHEW TREE (*Anacardium occidentale*).

(Tamil:—*Mindiri*. Telugu—*Jeedimamidi*. Malayalam—*Parangimanga* or *Cashmava*. Kannada—*Gera bija*. Hindi—*Kaju*.)

Introduction.—The cashew is a native of Tropical America. It is reported to have been introduced into the West Coast of India by the Portuguese some 400 years ago for the purpose of checking soil erosion on the coastal lands. The tree has become so naturalized in the West Coast that it now grows wild in the waste-lands of the West Coast.

The tree has attained commercial importance only within the past two decades with the rapid increase in demand for cashew kernels from foreign countries especially United States of America. In recent years, the cashew shell oil also has come into prominence owing to the discovery of many uses for it. Cashew apple, gum from the bark of the tree and timber are the other products of the tree, useful to man. The importance of the crop at the present juncture as a dollar earner for the country is second only to that of jute and tea.

Acreage and production.—In India the main cashewnut belt lies in the coastal strip lying between the Western Ghats and Arabian Sea extending from Ratnagiri in the Bombay State right down to Cape Comorin. The main centres of cashew cultivation and production are Ratnagiri and North Kanara districts in Bombay, Goa, South Kanara and Malabar districts in Madras and the United States of Travancore and Cochin. The tree has also in recent years been introduced into Bengal, Orissa and Mysore. In the Madras State, besides the West Coast districts of Malabar and South Kanara, cashew is being grown in the districts of Tirunelveli, East Godavari, Visakhapatnam, Guntur, Tanjore, Chingleput and South Arcot.

In the cashewnut Marketing Report published in 1944, the acreage under the crop in Madras was estimated at 45,000 acres of which 60 per cent was accounted for by Malabar and South Kanara. Since then there has, undoubtedly, been further increase in the acreage owing to the heavy demand for the kernels from foreign countries and the prevalence of attractive prices.

The annual production of cashewnut in India is estimated at about 45,000 tons, though in a good year the production may be as high as 60,000 tons, valued at 7 crores of rupees. A rough

estimate of the proportion of the total production from the important producing areas is as follows:—

	PER CENT.
Madras	50·2
The United States of Travancore and Cochin ...	36·5
Bombay	9·7
Bengal	1·2
Orissa	1·1
Mysore	0·5

Madras State is by far the most important State as far as cashewnut production is concerned.

Exports and imports.—India ranks as the most important producer of cashewnut in the world and holds almost a monopoly accounting for more than 95 per cent of the international trade in cashewnut kernels. Up to 1925, the quantity exported did not exceed 50 tons. Later on, however, it grew rapidly. In 1941–42 the quantity exported amounted to 19,923 tons valued at Rs. 209 lakhs. During war years there was a decline, but with the cessation of hostilities the trade recovered. In 1945–46, 12,059 tons valued at Rs. 572 lakhs were exported. In 1948–49, the exports showed considerable rise, it being 18,285 tons of kernels valued at Rs. 493 lakhs.

During the triennium ending 1941–42, the quantity of ceshew oil exported averaged to 1,078 tons per annum. In 1948–49 shell oil worth half a million dollars was exported to America, besides large quantities shipped to Canada and the United Kingdom.

The present production of cashewnuts estimated at 45,000 tons is not enough to meet the demand for export of cashew kernels. It is only sufficient to keep the cashewnut curing and processing industry going for about a period of seven months in the year. Large quantities of raw cashewnut are, therefore, imported every year, practically all from Africa mainly Portuguese East Africa, to be processed and exported as cashew kernels. In the triennium ending 1940–41, the imports averaged to about 28,000 tons per annum. In 1948–49 about 41,000 tons of raw nuts were imported.

Cultivation of the cashew—Soil and climate.—Cashew tree is hardy and drought resistant and is not very fastidious about its soil and climatic requirements. It flourishes on all types of soil from pure sand to laterite, on steep hill slopes and on extremely stoney soils with out-crops of rocks. It is therefore an ideal crop for cultivation in the wastelands and soils of low fertility where no other crops can be profitably grown. It does well in the plains up to an elevation of 1,500 feet above the sea level. The tree comes up well on the West Coast with an annual rainfall ranging from 120 to 150 inches and equally well on the east coast with only an annual rainfall of about 35 inches. The tree cannot stand frost. Nearness to sea is another factor reported to influence the productivity of cashew trees. Satisfactory yields are obtained only within 40 to 50 miles from the sea.

Seeds and sowing.—Seeds are generally planted direct in the pits 1 to 1½ feet cube previously dug 20 feet apart both ways and refilled to about three-fourths the depth with good surface soil, at the beginning of the south-west monsoon after one or two soaking rains. Two nuts may be sown in each pit to allow for bad germination or replacing the unthrifty seedlings in the later stages. Sometimes the seeds are planted giving a spacing of 10 feet by 10 feet, thinning being done later on as trees grow up, to give more space. The practice of raising seedlings in baskets filled with good soil and coir dust or fibre and transplanting them in the field during rains is also in vogue in certain localities.

After cultivation.—After planting, the trees seldom receive any attention by way of cultivation or manuring though these operations improve the yield of nuts. Some catch crops can, however, be taken for the first few years if the soil and local conditions permit. This would provide some subsidiary income and also benefit the plantation indirectly.

Harvest and yields.—The trees generally begin to yield from the third or the fourth year. Full bearing will commence from the eighth to tenth year and will continue for another 20 years before decline sets in. The life of a tree may be from 30 to 40 years.

Flowers appear in panicles at the ends of branches from about November to January and the fruits begin to ripen by February-March to May-June. The harvest of the ripe nuts is done periodically. Very often if the ripe fruits are not harvested in time, bats, birds and squirrels eat the apples and drop the nuts on the ground from where they are collected.

The annual average yield of a tree in full bearing has been computed at 20 lb. on the West Coast, 30 lb. in South Arcot and Visakhapatnam and 40 lb. in parts of Orissa. Yields as high as 100 lb. per tree have also been recorded from fully developed trees growing in favoured situations.

Processing of the raw nuts.—The kernels from the nuts are the chief product for which cashew is valued. To obtain them the raw nuts harvested are cured which process includes such processes as roasting, shelling, peeling, sweating and finally grading and packing. The raw nuts harvested are dried in the sun for a day or two and then roasted in small lots in shallow open pans over direct fire. This method is wasteful in that the valued shell oil is completely lost. In the improved processes now being adopted by large firms, the nuts are roasted in rotary cylinders or by passing them through a bath filled with cashew shell oil and kept at a temperature of 370 to 380° F. This not only helps to roast the nuts uniformly to the desired degree but also recover a large percentage of the cashew shell oil.

The shelling of the roasted nuts is done entirely by human labour. The proportion of kernels to whole nuts that may be

obtained is about 25 to 30 per cent. The kernels are again dried either in the sun or in specially constructed hot air chambers with a view to facilitating the removal of the thin brownish skin which gets shivelled during the treatment. The outturn of peeled kernels to unpeeled works out to 88 per cent. The peeled kernels are slightly moistened or sweated again to prevent breakage in transit. The blanched cashew kernels are then graded according to market requirements and packed in vacuum with or without carbon-dioxide.

Cashew apple.—The cashew apple is really the swollen stalk to which the nut is attached. It is two or three and half inches in length and has a thin skin which may be bright yellow or scarlet of different intensities. On on average a tree may yield about 75 lb. of apples per annum.

Research.—Work on the improvement of the crop was taken up from time to time at the Agricultural Research Stations, Taliparamba and Nileshwar III, and Fruit Research Station, Kodur, where cashew trees are growing. The results are summarised below.

Evolution of strains.—No strain has been evolved so far in the cashew. However, as a result of detailed observations on the yield and quality of nuts of individual trees growing in the research stations, high-yielding trees with heavy nuts and other desirable qualities have been marked out. For seed purposes only medium sized, heavy, well-developed nuts from fully ripe fruits of these trees are selected. Being a cross-pollinated crop, trees raised from nuts do not generally breed true to type, but experience from actual planting has shown that the desirable characters are inherited to a large extent.

Study of the variation in morphological and economic characters.—The population of trees growing at the Agricultural Research stations is a mixture of types, and detailed study of individual trees in respect of the various morphological and economic characters was made in order to have an idea of the extent of variations present. Variations were found to exist in all measurable characters as can be seen from the following statement :—

Character.	Range of variations observed. Maximum.	Minimum.	Mean.	Remarks.
(1)	(2)	(3)	(4)	(5)
1. Yield of nuts per tree ..	1,460 nos.	12	..	Data gathered at Kodur in 1943.
	1250	50	..	Data gathered at Kodur in 1944.

Character.	Range of variations observed. Maximum.	Minimum.	Mean.	Remarks.
(1)	(2)	(3)	(4)	(5)
1 Yield of nuts per tree—*cont.*	3,319	379	1,824	Data collected of a few cashewnut types at Agricultural Research Station, Taliparamba in 1936–37 and 1937–38.
2 Number of nuts per Madras measure.	430	195	305	
3 Weight of nuts per Madras measure.	2 lb.–14 oz.	2 lb.–11 oz.	2 lb. –12 oz.	
4 Number of nuts per lb.	153	72	110	
5 Number of fruits per lb.	24	8	13·4	
6 Weight of apple alone (oz.)	2·4	0·7	1·49	
7 Weight of juice per apple (oz.).	1·1	0·3	0·69	
8 Volume of juice (cc) per apple.	31·5	10·6	20·3	
9 Weight of kernels from 100 nuts (oz.).	7	2	5·3	
10 Percentage of apple to fruit by weight.	91·4	82·4	88·8	
11 Percentage of nuts to fruit by weight.	17·6	8·6	11·2	
12 Percentage of kernel to nut by weight.	48·0	30·0	40·2	
13 Percentage of juice to apple by weight.	61·7	34·1	47·2	
14 Percentage of shell to nut by weight.	70	52	59·8	

Similar observations were made at the Agricultural Research Station, Nileshwar III, also. These differences persist from year to year and point out to the definite possibility of evolving superior types by selection and hybridization.

Agronomic trials—Manurial experiment.—To find out the response of the cashew to manuring and cultivation, an experiment was started at the Agricultural Research Station, Nileshwar III, in 1942. Ammonium sulphate (1 lb.), bone meal (1 lb.) and ash (10 lb.) per tree per year were applied singly and in combination. The trees receiving all the manures gave better yields than those receiving one of the manures alone. Experience at Agricultural Research Station, Taliparamba, also showed that cashew responded to cultural and manurial treatments.

Studies on vegetative propagation.—Being a cross pollinated crop, progenies raised from nuts do not breed true to type. Trials to propagate the tree by vegetative propagation methods such as cuttings, layering, side grafting, inarching, patch and shield budding were done at the Fruit Research Station, Kodur, and the Agricultural Research Station, Taliparamba. Inarching and layering showed much promise while cuttings fared the worst. Layers made at Kodur in the rainy season struck root in all cases in two months and it was found advantageous to raise the layers in pots. The success of layering was 40 per cent in a trial done in December 1945 at Taliparamba. Inarching at Kodur gave an equally high 'take'. Trials to see whether application of root promoting hormone will promote satisfactory rooting of cuttings have been taken

up at the Agricultural Research Station, Nileshwar, but no conclusive results have as yet been obtained.

Nursery studies—(i) *Depth of sowing and position of nuts and germination.*—The fleshy and delicious cotyledons of the germinating nuts are very much liked by birds, jackals and rodents and they do considerable damage to the nursery. In one year, as many as 34 per cent of the sprouts were damaged or destroyed at Taliparamba. To see whether the depth of sowing and position of nuts have any bearing on germination and extent of damage, trials were made at the Agricultural Research Station, Taliparamba, in 1944–45. Seednuts were sown in the upright position, with the suture slanting and facing upwards with the suture slanting but facing downwards and on the side the suture being horizontal, at two different depths, viz., one inch and two inches. Maximum germination was obtained in the case of nuts sown in a slanting position with the suture facing upwards. The damage to sprouts was entirely confined to the nuts sown at a depth of one inch below ground level; the lot sown at two inches deep being completey free from damage. The necessity for sowing seeds deep is thus obvious.

(ii) *Size and weight of nuts and germination.*—The influence of the size and weight of nuts on germination was investigated at the Agricutural Research Station, Nileshwar III, in 1937–38. The variants under comparison included big nuts, small nuts, bulged nuts, flat nuts, heavy nuts (sinking in water) and light nuts (floating in water). Big sized and heavy nuts gave the maximum germination, while flat and light nuts recorded minimum values. It is concluded that for seed purposes only large sized and heavy nuts should be selected even from desirable trees.

(iii) *Maturity of the nut and germination.*—There is a belief among the ryots that seeds not quite fully mature (i.e., nuts collected when the apple is fully grown and is about to change colour in a day or two) are better for seed purposes than fully mature ones. This was tested at the Agricultural Research Station, Nileshwar III. The data gathered failed to show difference between the two groups of nuts in any of the characters studied, viz., percentage of germination, time taken for germination, height of seedlings and the number of leaves when the seedlings are three months old.

(iv) *Germination of nuts sown with and without the apple.*—A trial was carried out at the Agricultural Research Station, Nileshwar III, in 1941–42 to find out whether sowing cashewnuts with or without the fleshy apple is better. Data gathered showed that nuts without the apple germinated earlier. However, there was no difference between the two in respect of total germination, height of seedlings or the number of leaves of three months old seedlings.

(v) *Germination and differences due to locality.*—To find out whether the seednuts obtained from different localities exhibit difference in regard to germination and growth of seedlings, an

experiment was conducted at the Agricultural Research Station, Nileshwar III. Seednuts collected from red soil tract of Kasaragod, and red and sandy soil areas of Nileshwar were sown and studied. There was no difference either in germination or growth among the lots collected from the different localities.

Floral biology.—Studies in the biology of the cashewnut flower were made both at Kodur and Taliparamba. The inflorescence is terminal, polygamous and similar in floral structure to mango. For the first 2 to 14 weeks of flowering, the flowers produced are mostly male whereas the flower panicles produced about one to 3 months after the onset of flowering show a large preponderance of bi-sexual flowers. The bi-sexual flowers are larger in size than the male flowers. Anthesis is very active between 12–30 and 13–30 hours. The bi-sexual flowers open in the evening while male flowers open in the morning. The stigma is receptive in the morning. The proportion of bi-sexual flowers that set fruit is as low as one per cent. In controlled cross-pollination, 13·6 per cent of the flowers fertilized developed into fruits and this appears to suggest that want of efficient pollination in nature might be the reason for the poor setting of fruits observed. Unlike in mango, flowering in cashew is always preceded by a growth flush.

Preparation of cashew syrup.—As already stated, cashew apple is one of the important bi-products of the cashew tree. The apples cannot be preserved for any length of time as they will deteriorate rapidly. The Bio-Chemist, Kodur, has worked out a method of preparing cashew apple syrup.

An efficient method for the packing and storage of cashew kernels.—The Government Agricultural Chemist in collaboration with the Agricultural Entomologist carried out certain investigations on the packing and storage of cashew kernels. The kernels were preserved under different storage conditions, viz., (1) vacuum, (2) Co2 atmosphere (20 per cent) and (3) at atmospheric conditions for a period of three months and studied the deterioration and insect damage. All the samples were free from insect attack. However, the sample kept in vacuum was superior to others from the point of view of both acidity and rancidity, which are the criteria of the quality of the kernels. The study indicated the possibility of preserving the kernels free from insect attack and deterioration by packing them asceptically after sterilization (55°C) in vacuum, using, for the purpose, clean disinfected or sterilized tin containers.

Desiccation of cashew apples.—The loss of weight in red and yellow-coloured cashew apples on exposure to sun for five hours was studied at the Agricultural Research Station, Nileshwar III. It was found that the loss in weight was significantly more in the case of red-coloured apples.

CHAPTER 15.

DRUGS, NARCOTICS AND OTHER CROPS.

Henbane, Coca, Camphor, Chicory, Ipecacuanha, Jalap, Senna Ganja, Tobacco, chewing and smoking varieties, strains evolved, grading and marketing—The Central Tobacco Committee—Betel-vine, Tephrosia Vogelii, Pyrethrum, Derris, Stink grass, Kapok, Little rice, Tung oil, Indigo, cultivation and industry—Kudzu vine, Ratan cane, water chestnut.

Introduction.—In India, the indigenous ' Ayurvedic system ' of medicine makes use of various plants noted for their medicinal properties, and physicians collect these medicinal plants from various sources. The collection, however, is difficult and defective for want of correct and standard names of the plants. Much confusion is caused since the same plants are known by different names in different tracts. To remedy this defect and to have plants of medicinal value systematically collected, classified and identified, the Madras Agricultural department undertook to start a garden of medicinal plants. The first attempt in this direction was made in 1878 in an area of two acres in the Botanic Gardens, Ootacamund. Other factors also contributed to the development of this work. In 1923, Nilgiri Jalap found a very good market in London as it contained a high percentage of active resine. Therefore, the jalap plant was cultivated on a fairly large scale in the gardens. Later, seeds of several medicinal, insecticidal and other useful plants were obtained from various sources by the department and tried at several places. It was found that some of the plants could be successfully grown in the Madras State. A short account of the plants studied is given below.

1. Henbane (*Hyoscyamus muticus*) (*Solanaceae*).

This crop the leaves of which are used in the preparation of a tincture was cultivated at Koilpatti Farm (Tirunelveli district) for the first time in 1916 at the request of a Tuticorin firm. After making many attempts to ascertain the best system of cultivating the crop, it was grown successfully on a five cent plot. Ninety pounds of dried leaves were obtained from the plot and the produce was forwarded to the Medical Store, Madras; and a small quantity was also sent to the Imperial Institute, London. The Medical Store-keeper to the Government of Madras reported that the tincture prepared from the produce was tested and found to be satisfactory .The Imperial Institute, London, also reported favourably and suggested that the cultivation of Henbane might be continued.

2. Coca plant (*Erythroxylum Coca*) (*Lineae*).

The Coca plant (*Erythroxylum Coca*) is a small shrub indigenous to Peru, Bolivia, Columbia, Brazil and Argentine. It is the source of the alkaloid cocaine which is extracted from the leaves. Peru and Bolivia alone produce annualy about 15,000 tons of dry coca leaves containing 0·5 to 2·6 per cent. of various alkaloids including 0·2 to 0·8 per cent. of cocaine.

In Brazil, and other parts of South America, it grows at an elevation of 2,000—6,000 feet above the sea level. There are several varieties of the coca plant, of which the following two are important: (1) *E. Coca* (Var. *typica*) and (2) *E. Coca* (*var*) *novo granatense*. In Madras, Ceylon and Mysore, it is grown only for experimental purposes. Various attempts were made to grow coca in India, and the plants cultivated in Madras, on the slopes of Nilgiris, throve much better than elsewhere.

The plant thrives best at elevations of 2,000 to 5,000 feet. The temperature at this level does not fall below 60°F and the climate is free from sudden changes. Like coffee, coca does best on mountain slopes with perfect drainage. Shade is said to be unfavourable for the formation of the alkaloid in the leaves.

The plant comes up successfully in well drained, moist loam, rich in humus; but, as it is an exhausting crop, heavy manuring is necessary. The crop requires large quantities of potash and nitrogen. Good rainfall is essential and a heavy crop may be expected, 18 months after the time of planting. The plants may be raised from cuttings; and if cultivated on a large scale, seedlings eight to ten inches high will be required. There must be a liberal supply of water to aid germination. When once the plantation is successfully established, it lasts for 40 years. The percentage of alkaloids in the leaves goes on increasing up to ten years, keeps at a constant level up to 20 years and afterwards gradually falls down till the fortieth year.

The leaves are ready for gathering when they become rigid and break on folding. Two to four crops can be obtained in rich soils in a year. The leaves are picked singly and care must be taken not to pluck young leaves or shoots. A dry day should be chosen for the harvest, and the picking should not be carried after noon time, since several hours of sun-drying are necessary after picking. The completely dried leaves are put aside for a day or two and then packed. Air-tight packages similar to those used for tea are the best.

Preparation of the Alkaloid from the leaves.—The coca leaves contain several alkaloids derived from ecgonine, the most important of which is cocaine. The percentage of total alkaloids present in the commercial leaves varies from 0·1 to 2·4, Java coca containing the highest amount, consisting largely of cinnamyl cocaine. Crude cocaine is obtained, by mixing the dried leaf powder with

slaked lime and extracting with ether. The crude alkaloid is then purified by acid treatment and by suitable chemical methods.

There are several varieties of coca, and the typical one that can be best grown at higher elevations, is *E. Coca*, if the object is to obtain a large quantity of crystallizable cocaine. The *Novograntense* thrives at sea level in the tropics and yields nearly if not quite as high a percentage of total cocaine as *E. Coca*, but a large proportion of it is, with the present chemical methods, uncrystallizable. The latter seems to give a larger crop of leaves but fruits more sparingly.

It has been clearly established that the climate and physical conditions of many parts of India are well suited for the growth of coca, but whether its cultivation will be remunerative is another question. The Indian plant is generally richer in alkaloid content than the foreign material.

3. Camphor (*Cinnamomum camphora*) (*Lauraceae*).

The department obtained 50 young plants from Ceylon in 1909 and planted them at the Agricultural Reserach Station, Taliparamba (Malabar district). Twenty-five plants survived but they were not progressing well. They suffered from " die back " of the branches, and the best was only 20 feet high. The cultivation of camphor was tried by a number of planters on the hills. A few trees are grown in the estates on the Nilgiris but no attempt has yet been made for the sublimation of camphor. A number of trees are growing in the botanical gardens, Ootacamund.

4. Chicory (*Cichorium intybus*) (*Compositae*).

It was grown on the Central Farm, Coimbatore, in 1918 to 1919 and 1920 and also 1933–34. In all these years, it was grown as an irrigated crop, and yielded about 35,000 lb. of dried root per acre on the average. The crop was grown at the instance of Messrs. Stanes & Co., Coimbatore, and the produce was also sold to the same company.

The common chicory grows wild in many parts of Europe and India, in fields and on road sides. This wild parennial is now cultivated in many parts of the world, (1) to be eaten uncooked as a salad, or (2) to be cooked or stewed and eaten or (3) as fodder for cattle; or (4) for its roots which are roasted and powdered and used alone or mixed with coffee. The chicory root is long, like carrot or radish, and is of a dirty brownish yellow colour outside and white within. The bark of the root is rather thin. The taste is bitter and mucilaginous. The green root is fleshy like radish.

The chicory is a very hardy plant, growing well in all parts of India in a variety of soils. It is a very profitable crop of both poor sandy soils and richer lands. To obtain the best roots, large and fleshy and thick, an open situation and a rather light or somewhat sandy, and moderately rich soil is the best. Some

planters are of the opinion that the best roots are produced in South India, at an elevation of 2,000 to 6,000 feet above the sea level. But Mon. Acharat, a botanist, was growing excellent roots in the Government gardens at Pondicherry.

The preparation of the land for growing chicory is the same as for lettuce and endive. To get good roots, deep ploughing is good and necessary to pulverise the surface and work up to a fine tilth.

Seed may be sown in the plains in August, September and October. If sown much earlier, in May or June for example, many plants will soon run to seed. Chicory seeds look like lettuce seeds. The seed rate is four pounds per acre. The seeds are generally sown in drills 12 to 15 inches apart. Best roots are obtained when seeds are sown in lines two feet apart; the young plants should be thinned out to give the required spacing. The best roots are produced only if the plants are allowed to grow where they were sown, without being transplanted. The soil has to be kept moist by light irrigation.

The soil must be kept open, by hoeing occasionally between the rows. The best roots are got with the plants grown single. If four or five plants grow together in one place, the roots will be thin and woody, and therefore inferior. If chicory is grown as fodder for cattle, 7 to 12 lb. of seeds per acre should be sown broadcast. Some of the best meadows are thus cultivated in France and Lombardy.

The crop is ready for harvest in three to four months from the date of sowing. The roots are generally dug up in January in India. Chicory is largely grown in Lahore, and other parts of the Punjab, and is considered there to be a very paying crop. A yield of about 5,500 lb. of superior green roots per acre can be obtained when the spacing given is two feet by one foot. But in many parts of Europe, they grow chicory about eight inches apart in the line, with rows 12 to 15 inches apart and the outturn is more than double the above estimate. Besides the roots, the leaves also can be cooked and eaten, or fed to cattle.

For over a century, chicory root has been used as a substitute for coffee or to mix with coffee. The roots are pulled up, washed, cut into small pieces and dried (in a kiln in Europe). When dried, the roots get shrivelled up, and weigh not more than one-fourth of the weight of the green roots. The dried roots are then roasted in heated iron cylinders, which are kept revolving as in coffee roasting during which process they further lose 25 to 30 per cent of their weight and give off a disagreeable odour. If, while roasting the root 2 lb. of butter or ghee is added to every 112 lb. of chicory, it imparts to it much of the general appearance of coffee, and improves the flavour. It is then hand-picked to remove foreign matter and is then reduced to powder. It is sold separately as chicory powder, or is added to ordinary ground coffee, and sold as

a coffee mixture. Its main use in coffee is to impart a deep brown colour to the coffee decoction.

5. IPECACUANHA (*Cephœlis ipecacuanha*) (*Rubiacea*).

Trials with seeds of Ipecacuanha were conducted at Ootacamund, Nanjanad, Coonoor, Anakapalle, Aduthurai, Wynad and Siruguppa stations. Germination was not reported from any of the stations. But in Kallar gardens the plants were grown for several years but without much success. In 1936–37 one pound of root samples were analysed by the Medical Stores and the analysis was found unsatisfactory as the proportion of Cephalin to total alkaloids was high.

6. JALAP (*Ipomœa purga*) (*Convolvulaceœ*).

A block of land in the Botanical gardens at Ootacamund which was cleared of jungle growth was fenced and a portion measuring 22 cents was planted with 219 lb. of jalap tubers. A number of these weighed as much as a pound each and were, therefore, not of an economical size for planting, two ounce tubers being the correct weight. The tubers were planted in April 1923 and the crop when lifted in March 1924 weighed 1,200 lb. giving a yield of approximately fourfold.

When the crop was being lifted, it was noticed that there were many undeveloped tubers attached to the stolons, and from this fact, it was presumed that the tubers should remain in the ground for a period of about two to three years before they are harvested. From the results so far obtained, there can be no doubt that jalap can be grown profitably on the Nilgiris.

There has been no development in the cultivation of jalap tubers on a commercial basis since 1926. Experiments were conducted on the cultivation of this plant in the Botanic gardens on the Nilgiris from 1922 to 1926. Since there was no demand from the Medical Store for further supplies, its cultivation was discontinued.

7. TINNEVELLY SENNA. (*Cassia angustifolia*) (*Leguminosœ*).

Tinnevelly senna has got a very good market in the United Kingdom. The leaves and pods are sold in London at the monthly Drug Auctions. The crop is grown in Tirunelveli and Ramanathapuram districts.

(1) *Soils.*—Senna is cultivated on dry land, unirrigated both as a pure and a mixed crop and in single crop rice land as a subsidiary crop. Of late, however, it is also grown under irrigation from wells. Red and black loams are best suited for the cultivation of the crop.

(2) *Seed rate.*—Nine pounds per acre is the ordinary seed rate; 12–15 lb. of seed being also adopted in some places. The seed rate for garden land and wet land is only three to six pounds.

(3) *Season.*—The season for raising the crop should be so selected that there are no heavy rains during the early stages of growth and very little or no rain when the leaves are gathered. The crop may either be treated as an annual which is the practice when it is raised in rice land or when raised on dry lands kept for two or more years. Three months after sowing the crop, the first picking is taken. Thus the season for sowing senna varies according as it is raised in the dry land, rice land, or land under well irrigation.

Dry land crop (Tirunelveli district).—The lands are well ploughed (two to four ploughings) in August-September and towards the end of the north-east monsoon, that is in December, the seed is sown. One hoeing and weeding is given in January; a subsequent hœing may be given a fortnight later. In about two months flower buds appear, which are generally nipped off so as to encourage leaf growth. In March the crop is about two and a half to three feet high when the first picking of leaves is made. The bottom leaves only are then collected and the second picking is taken about a month and a half or two months later. An inter-cultivation with the country plough soon after the first picking is beneficial.

Very often the dry land crop is removed after two pickings. But if the rains are well-distributed and the thunder showers of April are favourable, it is usual to allow the crop to stand till the following December-January. In such instances, one picking is taken in August-September and one in each of the succeeding months.

When the crop is intended to stand for a number of years, it is usual to sow horsegram (*Dolichos biflorus*) with the rains in August-September after a picking is taken, or gingelly in December-January. Thus the ploughing given to sow horsegram or gingelly, serves as an intercultivation for the senna crop.

If the north-east monsoon is heavy, leaves cannot be gathered.

Crop under well irrigation.—After the harvest of a grain crop usually of *ragi* (*Eleusine coracana*) the land is ploughed and senna is sown. One or two waterings are given before a picking is taken. After the first picking, one or two irrigations are given and a good second picking is taken. By the end of July, the cultivation of senna in garden lands closes when the lands are ploughed and kept ready for a grain crop.

Rice land crop.—As soon as the second crop of rice is harvested in February or March, the land is ploughed when there is still sufficient moisture for the germination of seed, and the senna seeds are sown.

Whether the ryots understand the fact or not, it is a very good practice to grow senna, a leguminuous crop, instead of gingelly which is an exhausting one. This appears to be doubted by some ryots, for they are of opinion that senna also is an exhausting crop.

Curing.—There is no regular system adopted in the curing of the leaves. The day's picking is dried in the shade; while drying, the leaves should be turned from time to time; when well-dried they are packed in sacks. In certain villages long sheds are erected to dry the leaves when it takes three or four days for the leaves to get dry. Sun drying imparts a yellow or a brown colour to the leaves, while those dried in the shade are green or bluish green. Leaves should never be dried in the sun, if it can possibly be avoided.

Yield and value.—The yield varies according to the nature of the soil treatment given to the land, and the crop, etc. About 250 lb. of leaf can be gathered from an acre of dry land crop. If the rains are favourable and well distributed, the yield may be 500 lb. and more; in rice lands and under well irrigation, it may be as high as 1,000 lb. per acre.

The price of senna is subject to considerable fluctuations and depends partly upon the demand for it in the European and American markets, upon the quality of the leaves, and on competition among the local dealers.

The leaves from the dry land crop are generally small but those from the garden or wet lands are larger and fetch a higher price.

8. Rhamnus Purshiana (*Cascara Sagrada*) (*Rhamneæ*).

The cultivation of the species proved unsuccessful at the Agricultural Research Stations of the Department.

9. The Ganja or Hemp plant (*Cannabis sativa*) (*Cannabinaceæ*).

During 1926–27, a preliminary study of the cultivation of 'Ganja' crop was made at the Agricultural College, Coimbatore.

The crop was raised in the Central Farm, Coimbatore with variety *Baggupad* sown by the end of August.

Germination.—Seed soaked in water for 24 hours begins to germinate in about 24 to 30 hours. In the field, seedlings first appear seven days after sowing. During germination the cotyledons are brought above the ground by the lengthening of the hypocotyledonary loop, and they function as green leaves for about 15 days and then wither and fall of.

A number of germination tests, showed that the percentage of germination of seed as also its weight, to some extent, decreases with age.

The sex of seedlings could not be determined from morphological characters. Flower buds were first observed 45 days after germination. Male buds could easily be identified and distinguished from the female ones; consequently male plants could be rogued out at this stage. The male flowers begin to open at about eight (8 a.m.) and continue to do so till 11 a.m. In about 30 minutes

after the opening of the male flowers the pollen grains are completely shed—the anthers hanging down from the slender filaments being easily shaken even by a very gentle breeze. Pollination is entirely brought about by wind through insects like the Mellipona bees which are found frequently visiting the male flowers, but they are never found on female flowers.

Pollen grains remain viable for 24–30 hours after the dehiscence of anthers under laboratory conditions. Various media were tried for germinating pollen grains artificially in the laboratory. Only ten per cent. glucose solution in distilled water proved successful. The first signs of germination were observed in three hours.

Dimensions of pollen grains and germ tubes.—The pollen grains are spherical bodies, pale yellow in colour, with thin walls. The diameter of the grains varies from 30 to 36 μ. Width of germ tube is seven to ten μ and the maximum length observed is 150 μ. The non-sticky powder-like mass of pollen grain becomes shrivelled up in 24 hours under laboratory conditions, but they regain their normal shape when treated with water or dilute glycerine.

Resin secretion.—Stalked glands on the bracts of female flowers could be easily seen when the plant is about 60 days old, though stickiness and smell are not perceptible. Such stalked glands are absent in the male plants. The glands become sticky when the plant is about 90 days old, and the inflorescence when rubbed in the hand emits a sort of mango smell, characteristic of fresh ganja. This smell and viscidity are markedly noticed in all plants that have set seed as the glands which contain the active principle of ' Ganja ' are well-developed in such plants. But in isolated female plants where the flowers were not fertilized the formation of the glands was poor and the characteristic smell was not very perceptible.

Types of plants.—Plants with green stems and broad leaflets predominate, and those with green stems and narrow leaves could also be seen. There were many plants with purple or striped stems either with narrow or broad leaves. Apart from the colour of the stem and the size of the leaves, the following characters are interesting from the point of resin, or ' Ganja ' production :—

Type 1.—Branching profuse with the female spikes very compact and dense having small narrow leaves. This is the most desirable type of plant for purposes of ' Ganja ' manufacture.

Type 2.—Inflorescence thick and compact but with too many large leaves which diminish the value of good ganja.

Type 3.—Inflorescence lax with flowers distantly arranged. This type of plant naturally yields a very small quantity of ' Ganja ' and is undesirable. Such plants are more commonly met with in the purple stemmed form than in the green one.

Seeds of the various types of plants were selected for trials. It may be that some of the red stemmed plants are natural hybrids and as such they should be discarded for experimental purposes.

To find out exactly the types that breed true for the character selected the various kinds of seed had to be tried before fixing the types.

In this connexion it will be interesting to note the importance of seeds which will produce female plants only. By manipulation in crossing a small quantity of seed which should theoretically give rise to only female plants was produced.

Sexual expression and conversion of sex.—Besides the normal male and female plants, inter-sex types bearing both normal and abnormal male and female flowers are of common occurrence. Typical male plants that were drastically pruned produced branches bearing normal flowers of both the sexes. Abnormal flowers of fantastic combinations of the sexes were also found in profusion. Sex in ganja is undoubtedly capable of being largely influenced by environment and external stimuli.

The chemical aspect of the investigations regarding the deterioration and improved methods of storing ganja was undertaken by the Government Agricultural Chemist, Coimbatore and the following is the report.

The investigation had its origin as a result of the inspection of the ganja store houses at Vetapalem and Santhavasal by the Commissioner of Excise who felt that the loss of revenue consequent on the deterioration of ganja was due to the imperfect methods of storage. He made out a case impressing on the Government the need for the investigation by the Government Agricultural Chemist, and this was sanctioned by the Government. Preliminary investigations had shown that the conditions of storage needed improvements in certain directions for maintaining the quality. Experiments on the evaluation of the quality of stored ganja by chemical methods proved undependable. Physiological methods though capable of measurement of the intoxication produced by ganja, were still incapable of giving an index of the extent of the psychological effect on the smokers. For instance, an old sample of ganja which was found to produce intoxication in animals, was not found to make a smoker as happy as he would be if he smoked a fresh stuff. Consequently smoking trials were decided upon as the means of measuring the quality of ganja under different conditions of storage.

The bio-chemistry of the ganja plant was investigated. It was found that the resin is formed from carbohydrates, and that it is different from the ordinary resins in being mobile in the plant functioning as a reserve material under conditions favourable for fresh growth. There does not appear to exist any direct relationship between fertilization and resin production, and this work does not confirm the usually accepted idea that fertilization and seed production are detrimental to resin formation. Nevertheless, the necessity for the elimination of the male plants was explained. It would appear from a detailed examination that the factor responsible for the characteristic properties of the ganja consists of volatile

essential oil, and non-volatile oleo-resin. Under the conditions of storage the essential oil rapidly volatilises and the oleo-resin is slowly oxidised by the oxidising enzymes present in the ganja cake, and by air and heat. Besides, humidity also contributes to the deterioration of the cake. The findings of the investigations were applied to storage experiments both on the small scale in the laboratory, and on the large scale under the store house conditions and it was found that packing the ganja in oil paper, and storing it in completely filled, tin-lined wooden boxes, is capable of retarding the deterioration to a definite extent. In addition to the inevitable deterioration of ganja sooner or later owing to its inherent nature, and depending on the conditions of storage, there are other causes which may be called *internal* and *external* leading to the deterioration of ganja.

The internal causes are those arising from defective methods of cultivation and manufacture with which the Excise Department is directly connected, and the external causes are those which are brought about by licensees and stock holders and salesman. The former can be overcome by forming a separate ganja branch just like the distillary branch, and the latter by the Excise Department taking over all the business connected with ganja.

10. TOBACCO (*Nicotiana tabacum* and *Nicotiana rustica*).

(Tamil—*Pogailai.* Telugu—*Pogaku.* Malayalam—*Pogaila.* Kannada—*Hoge soppu.* Hindi—*Tamakku.*)

Production and importance.—Tobacco is a native of America and was comparatively unknown in India's trade about 150 years ago. The crop is cultivated and valued for the sake of its leaves, which when cured, are used for smoking, in its several forms as cigar, cigarette, *beedi*, pipe and *hookah*, for chewing and manufacture of snuff. It is also used for the preparation of decoctions and drugs required for treating certain maladies of men, cattle and plants. The plant was first introduced into India by the Portuguese towards the end of the sixteenth century. In the early days it was used for a long time only in the form of cigars. It was successfully grown for commercial purposes first in Gujerat (Bombay) and later confined to the Deccan for about a century before its subsequent expansion to the rest of India. Cigarettes which were unknown in the year 1860 are becoming increasingly popular throughout the world since then.

The cultivated types of tobacco fall under two botanical species, viz., *Nicotiana tabacum* and *Nicotiana rustica* belonging to the natural order *Solanaceæ*. Of the two species the *tabacum* possessing sessile or stalked leaves elongated and pointed and flowers coloured white or pink is extensively cultivated compared to *rustica* which is a hardy plant having rounded and stalked leaves and yellow flowers. In the cured state, the leaves of *rustica* have a higher nicotine content ranging from three to eight per cent. while in *tabacum* it seldom exceeds five per cent. the lower limit being

0.5 per cent. In Madras, practically the entire area under tobacco is grown with *tabacum* while *rustica* is raised in scattered blocks of the river islands of the Circars known as *lankas*.

The present area spread of the crop is an outstanding example of the changes brought in by new cash crops in the general agricultural practices of the country. It is now one of the important money crops of the Indian peasant and the India Government realise annually twenty-four crores of rupees in the form of excise duty alone. The crop also provides large scale employment to both skilled and unskilled labourers during a greater part of the year. Madras tops the list of tobacco producing States of India with roughly three lakh acres under the crop and contributes nearly a third of the total Indian production. In Madras, the normal yield of tobacco is about 1,000 pounds of cured leaf per acre and the annual production of the State is estimated at 1·13 lakh tons. The exports of raw and manufactured tobacco mainly to the United Kingdom amounted to about 20,000 tons valued at 5·6 crores of rupees during 1947–48. The district-war figures for the area and production of Madras State is detailed in Statement 1.

The several cultivated varieties of Madras are conveniently grouped, depending on the commercial use to which the tobacco is put, viz., cigarette, cigar, cheroot, chewing, snuff, *beedi* and *hookah*. The cigarette tobacco covers both the Virginia and the higher grades of indigenous tobacco. The bulk of the country tobacco is moderate in texture and cures into light, medium or dark brown shades of colour. The darker grades are used for chewing, pipe and cheroot, while the light and medium grades are preferred for cheap cigarettes. As tobacco is consumed in several forms, the quality requirements of the raw and cured leaf for each of the categories are different. The main factors are strength, aroma, burning character and ash which are closely associated with smoking quality. The colour, texture, size of leaf and freedom from blemish are the important external characters by which the tobacco is judged. Colour is the most important single criterion employed in judging quality as it is closely correlated with several characteristics which cannot be judged easily. Bright lemon yellow for cigarettes, light to dark brown for cigars and cheroots and orange to light green for *beedis*, are preferred. For snuff and *hookah*, no special stress is laid on colour while for chewing tobacco flavour is more important than colour. Texture which is largely associated with the body of the tobacco leaf indicates strength also to a certain extent. The thick leaves generally contain more nicotine and are therefore stronger than thin leaves. For cigarettes of a superior quality the leaf should be fine, thin and silky with some body but should not be papery. For cigars and cheroots, the wrapper leaf should be thin, smooth, glossy, pliable and free from prominent veins while for fillers the leaf may be medium or thick. In the manufacture of beedies, fairly thick leaves but not coarse ones are preferred. In the case of chewing tobacco though the leaf may be of variable texture, thick and coarse leaves are generally considered

inferior. The leaf used for *hookah* is usually thick and coarse. Leaves of all sizes exceeding six inches in length are used for cigarettes. But size is very important for chewing and cheroot tobacco, the larger leaves being preferred. For wrapping of cigars and cheroots the leaf should be large in size. Size of leaf however is not important in the case of 'fillers', snuff, *hookah* and *beedi*. Strength is perhaps the most important factor in smoking quality. Cigarette tobacco should be mild having a nicotine content of not more than two per cent. The pipe tobaccos are generally a little stronger. For mild cigars, the leaves used may have nicotine content ranging from 0·5 to 3·25 per cent. The common twisted cheroots of Madras are strong being made from leaf having a nicotine content up to 5·25 per cent. The leaf used for making *beedies* and for chewing contains 2·5 to 5·5 per cent with an average of four per cent while the tobacco used for *hookah* has three to seven per cent of nicotine.

The presence of diseased patches or sponged leaf is particularly objectionable in the case of cigarette, cigar and cheroot but relatively unimportant in other cases. A slow, continuous and regular burning is important for cigarette, cigar and cheroot while evenness of burning is particularly valued in cigar leaf. In all cases of smoking tobaccos except *hookah* whitish colour of the ash is important. Flavour or aroma is difficult to define and refers to the one developed when the tobacco is smoked, and is characteristic of the type of leaf. From the point of several characteristics enumerated above *Nicotiana tabacum* contains the qualities required for cigarette, cigar, cheroot, pipe and *beedi* while *Nicotiana rustica* with its high nicotine content is suitable for *hookah* and *beedi*.

Varieties and agricultural practices.—The Virginia tobacco which takes its name after the place of origin occupies an important place in the production of cigarette tobacco in Madras and India. It is cultivated to the tune of 1·40 lakh acre in Guntur and neighbouring districts of Krishna, East and West Godavari. Among the varieties, *Adcock* which was predominantly grown in earlier years has since been replaced by *Harrison Special* introduced into the area by the Indian Leaf Tobacco Development Company. *White Burley* an American type having very light colour and fine texture—is also cultivated to a certain extent in the Guntur district.

In Vishakapatnam district, country tobacco is grown on dry lands and used for cheroots. This tobacco is brown in colour and has medium texture with a mild to strong flavour. In Krishna and Godavari districts, tobacco is grown on islands of the deltas known as 'lankas'. Tobacco grown on the *lankas* of Godavari is very popular because of its mild, agreeable flavour and even burning qualities and is mainly used for cheroots, while that grown on the *lankas* of Krishna river is dark to brown in colour and possesses strong flavour. Tobacco grown in the areas other than the *lankas* in these districts is used for chewing, snuff and cheroots. In recent years, Virginia tobacco is spreading rapidly in these districts

due to the efforts of the Agricultural Department and of the premier tobacco firms in the State.

In the Coimbatore district, tobacco is grown mostly under well irrigation and varieties are named locally according to the shape of leaf, viz., *Yerumaikappal* (broad and large), *Vattakappal* (round), and *Usikappal* (narrow). Similar types are also cultivated in the districts of Tanjore, Tiruchirappalli, Madurai and Ramanathapuram under various local names. Many of these are dark brown to almost black in colour and mostly used for chewing or cheroots. The *Usikappal* of Coimbatore is of a superior quality having a mild flavour and is used as fillers in cheroots. The best types of chewing tobacco grown in the southern districts are the Sivapuri of South Arcot and Meenampalayam of Coimbatore, both of which are characterised by a special flavour of their own. Tobacco grown in the dry lands of Salem is used mainly for snuff and to a small extent for *beedis*. The periods of sowing, transplanting and harvest of the different types in the main tobacco growing districts of the State are given in Statement 2.

Tobacco grows most rapidly in warm climates although it is now cultivated under a very wide range of climatic conditions. Generally a moderate rainfall in the growing season followed by a dry period during processing stages are desirable. Excessive rainfall may cause injury to the crop principally through its effect on the soil, resulting in the leaching away of plant foods in the light soils and waterlogging in the heavier types. Production of spots on the leaf which brings down the quality of leaf in the case of Virginia tobacco is another damage caused by heavy rains. In the case of other ordinary varieties such heavy downpours are detrimental to the mature leaf which suffers in quality through washing away of the gums deposited on the leaf surface at that stage.

While tobacco can be grown commercially on many types of soil, the range for the production of any particular type is restricted. Under favourable conditions the plant tends to produce an enormous leaf area in a short period and naturally a very active root system is needed to support this development. The major soil conditions which contribute to the maximum leaf development are sufficient supplies of air, water and plant nutrients. In the Madras State tobacco is cultivated on a variety of soils ranging from coarse sands to heavy clays. In the South Kanara district, country tobacco used for chewing and snuff is grown on exceedingly sandy soils near the sea coast. In the southern districts it is grown on loamy soils under irrigation. In the Guntur area Virginia tobacco is grown in fertile black clay soils as a rainfed crop. In the Godavari and Krishna districts country tobacco is cultivated on *lanka* soils ranging from coarse sand to stiff loam. In the area around Chebrole in Guntur district, cheroot tobacco of very good reputation is grown on fertile, old village sites known as *pati* soils. Tobacco is a deep rooted crop with a wide spread of root system and the soils should therefore be deep and well-drained.

Rich and heavy types of soils tend to make the leaves bigger, thick, coarse and dark in colour suitable for chewing, cigar fillers, etc.

Proper rotation of the crop is an important factor affecting quality of leaf in tobacco. Any excess of nitrogen in the soil tends to give a dark colour to the cured leaf. Experience in Guntur has shown that it should not be grown in the same field more than once in three years and that it should not be preceded by nitrogen fixing legumes or heavily manured crop like chillies. Cereals like sorghum, dry rice and maize are found to be the best preceding crops. Cultural practices along with soil and climate play an important role in determining the type and quality of leaf produced. The spacing of the plants in the main field, the time of planting, time and height of topping, the stage of maturity at which the leaf is harvested and the method of harvesting are other major factors.

Varietal introductions and trials.—For a long time Madras has been growing only country tobacco and it was in the year 1920 that Virginia type was first grown near Guntur on an area of two acres as an emperimental measure with great success and in 1921 its cultivation was extended to forty acres. The Guntur tract was found to be particularly suitable for growing unirrigated tobacco because the soil retained the moisture for a long time. Generally under dry conditions a light coloured leaf is obtained. Further the climate of Guntur is suitable for the air and sun-curing systems on account of the dry atmosphere and practically rainless period from January to May. Under such favourable conditions the area of Virginia tobacco increased by leaps and bounds, and to-day Madras occupies a premier place in the cigarette tobacco producing states in India.

The Agricultural Research Station, Guntur, was opened in the year 1922 with the object of improving the two main crops of the tract, viz., cotton and tobacco. Varietal trials with *Virginia, Pusa* 28 and the *local* conducted for two seasons registered mean yields of 461, 476 and 487 pounds of cured leaf per acre respectively. In point of colour, *Pusa* 28 was found to be the best, *Virginia* ranked second and the local had a dark brown colour. The *Pusa* variety was however bitter in taste. In the subsequent years of 1924–28, trials with exotic varieties like *White Stem Ornoco, Adcock, Gold-leaf* and *White Burley* were conducted. *Gold leaf* gave poor yields while *White Stem Ornoco* did not suit the local market on account of its thick and overgrown leaves. *Adcock* and *White Burley* yielded on an average 782 and 718 pounds of cured leaf per acre respectively, while local gave 911 pounds. During 1928–29 three other Russian varieties were tried along with the above two exotic types. The former did not thrive well, the seedlings having come to flower in the nursery itself. The variety, *Harrison Special* which was first introduced by the Indian Leaf Tobacco Development Company was grown on the farm for the first time in 1931–32 and as a result of further work

on this variety, a strain HS 9 was evolved in 1938. This has proved to be very popular. In 1943–44 fresh seed of seven varieties obtained from Canada was raised in replicated plots. *Harrison Special*, *White Mammoth*, *Yellow Mammoth*, *Bonanza*, *Gold Dollar*, *Duquesne*, and *Havana* were compared with control HS 9. Two of the above mentioned varieties, viz., *Harrison Special* and *White Mammoth* were poor while the rest were on a par with control.

With a view to ascertain the quality and yield of cigarette tobacco which the soil and climate of particular areas can produce, exploratory stations at Vishakapatnam, Nandyal, Cuddalore, Salem and Ramanathapuram were opened in 1948 with the financial assistance of the Indian Central Tobacco Committee. The results of varietal tests at these stations during 1948–49 are summarized below :—

At Yellamanchili in Vishakapatnam district where the soils are red, sandy on the surface and loamy in layers below, and deficient in nitrogen and calcium, an acre yield of 1,112 pounds of green leaf giving 174 pounds of flue cured tobacco and 48 pounds of rack cured tobacco was obtained. At Nandyal where the typical black soil is one of dark chocolate loam overlying a stiff yellow clay, cigarette tobacco HS. 9 grown over an area of six acres gave an average yield of 600 pounds of cured leaf per acre. The growth of the crop was good and the flue cured leaf was as good as Guntur leaf in quality, colour and body. At Sendarampatti in Salem district, the soils are sandy loams, calcareous and very poor in available phosphoric acid. An average yield of 632 pounds of shade cured leaf was registered.

Evolution of strains.—During the years 1922-33 bulk trials of some introduced varieties were conducted at the Agricultural Research Station, Guntur, the results of which are summarized elsewhere in this chapter. *White Burley* was a poor yielder while *White Stem Ornoco*, though high yielding, was coarse and found unfit for flue curing. *Harrison Special* and *Adcock* combined yield and quality. Single plant selections were made in these two types since 1932. *Adcock* 13 and HS. 9 were the two high yielding strains evolved, of which the latter was better for flue curing and satisfied the needs of the Guntur tract very well. It grows well and has the ideal type of leaf which develops good colour under favourable conditions. It also cures better, giving higher yields of top grades. It is claimed that this strain has covered nearly 95 per cent of the cigarette tobacco area.

Among the country varieties, broad leaf selection (*Type* 20) and narrow leaf selection (*Type* 16) were isolated in 1937–38 through single plant selection. *Type* 20 yields better than *Type* 16, but is not popular with the cultivators as the broad leaf of the former is not liked by them.

With a view to combine the desirable characters like aroma and flavour of the Virginia variety with the higher nicotine content of the local cheroot and *beedi* types, a series of crosses were effected and continued since 1939–40. No useful results have been obtained so far.

Agronomic trials and experiments.—No agronomic experiments on country tobacco have been conducted so far and the following trials relate only to cigarette tobacco.

Nursery practices including sowing.—In Guntur district, the cultivation of Virginia tobacco has become so specialized that a large proportion of the ryots depend for their seedlings upon professional nurserymen who raise nurseries on a commercial scale in the coastal sandy belts covering about 1,600 acres. The seedlings grown in these sandy soils establish much better than those from black soils due to their large fibrous root system and are therefore in great demand for export to Nellore, Krishna and Godavari districts. Further the nurseries in black-soils often fail due to damage by the 'damping off' disease. Though no specific experiments on nursery practice have been conducted it may be stated that, on the basis of experience gained at the Agricultural Research Station, Guntur, good nurseries can be raised successfully on black-soils by adopting the following methods. A fertile, high level slopy land having low water table and commanding good irrigation source nearby is selected, ploughed well to obtain fine tilth and laid into long and conveniently wide beds. About three to four days prior to sowing the soil is sterilized by burning inflammable material like casuarina twigs, and the ashes are worked lightly into the soil. The seeds at the rate of two to two and half pounds per acre of nursery are mixed with fine sand and hand sown. The beds are watered frequently in the form of spray by a rose-can till the plants are about three weeks old. The seed beds may be covered with casuarina leaf to provide shade for the tender seedlings and to protect them from the beating action of heavy rains. Wherever the seedlings are crowded thinning is done and the plants so removed are utilized for planting the patchy areas. Ammonium sulphate at about 10-20 oz. per cent of nuresery area is applied if the seedlings are stunted and heavily watered immediately. One or two hand weedings are done. If proper attention to weeding and control of insect pests and diseases by periodical sprayings is given an acre of nursery will normally supply seedlings sufficient for planting an area of 100 acres. The following has proved to be an efficacious spray mixture for control of diseases in the nursery :—

Bouisol (colloidal copper)—1 ounce.
Lead arsenate—¼ ounce.
Agral (Spreader)—⅛ ounce.
Water—1 gallon.

Sand culture experiment.—An experiment was started in 1941–42 to find out whether by mixing sand in various proportions to the clayey soil, nurseries comparable to those of the sandy areas

could be raised on black-soil. The trials were conducted for two seasons with five variants, viz., pure clay, 25, 50 and 75 per cent sand mixtures and pure sand. In both the years, the germination was slow in the sandy seed bed and replicated yield tests with seedlings raised from such nurseries did not show significant differences.

Wilting experiment.—It is commonly believed that if the tobacco seedlings are allowed to wilt for some time before planting, the leaves develop better colour. An experiment on the above aspect was conducted for three seasons from 1941–42 with Virginia tobacco. The seedlings were allowed to wither for 0, 6, 12, 24, 48 and 72 hours before planting and the results showed that the establishment of seedlings was poor if the planting was delayed beyond 24 hours after lifting the seedlings from the nurseries. In the final yields, there were no significant differences among the various treatments. The popular belief about colour development was also not substantiated, since in the different years, different treatments showed better colour in the field.

Soil culture.—At the Agricultural Research Station, Guntur some ploughing experiments were conducted prior to 1940. But as these were non-replicated tests no valid conclusions could be drawn. An experiment with the object of determining the best possible pre-cultivation for Virginia tobacco was started in 1940 and the variants tested were (*a*) four ploughings, *guntaka* twice, and *gorru* twice, (*b*) *gorru* twice and *guntaka* twice, (*c*) ploughing twice and *gorru* twice, (*d*) ploughing twice and *guntaka* twice, (*e*) two ploughings only, *gorru* twice, *guntaka* twice; (*f*) and no ploughing. In all the three years of trial the maximum cultivation adopted in the first treatment gave the highest yield.

Manuring.—The results of experiments with green manures *pillipesara*, *teegapesara* and cowpea, with and without phosphoric acid were not consistent.

Manurial tests with artificials were conducted at the Agricultural Research Station, Guntur during the years 1928–34. Ammonium sulphate, sulphate of potash and superphosphate at one cwt., 50 lb. and one cwt. respectively and at double these doses, with and without a basal dressing of cattle manure were the variants tested. The application of cattle manure was done in two ways, viz., 12 tons per acre at one dose for a three year period or at four tons per acre every year during the three years. There was no difference between these two methods as judged by the crop response. The fertilizers in double doses were significantly better than the corresponding single doses. The highest increase was obtained in a combined application of nitrogen, potash and phophoric acid, the increases ranging from 13 to 22 per cent for the single and double doses over the control plots manured at four cart-loads of cattle manure per acre applied every year or 12 cart loads applied once in three years.

This system of export of tobacco under guaranteed grades has created a good reputation for the quality of Indian tobacco in export markets and favourable reports have been received from foreign importers.

Tobacco seed-oil and cake.—It is only the country tobacco that is generally topped to make the leaves grow bigger, thicker and more pungent while Virginia type, on the other hand, is allowed freely to flower and set seed to facilitate development of leaf qualities desirable for cigarette tobacco. No attempt, however, is made on the part of the grower to collect the seed from the latter and the dried stalks are usually burnt along with the capsules. Cattle, goats and sheep also feed on the capsules and the seed imperceptibly finds its way to the manure pits thus acting as a serious source of contamination of the nursery. Preliminary estimates of production showed that the Virginia tobacco seed thus produced and wasted was not inconsiderable and that an extra income of Rs. 25 per acre could be realised by proper collection of the 150 to 250 lb. of seed produced per acre. The seed contains 25 to 30 per cent. of oil as compared to about 40 per cent. in the case of gingelly. The tobacco seed oil looks, smells and tastes like gingelly oil without any unpleasant taste or flavour.

In 1944–45, work was initiated under the auspices of a special scheme to explore the economic possibilities of tobacco seed oil. Small scale trials of extraction of oil were conducted adopting three methods, viz., hot water process, country chekku and screw press system adopted for the extraction of castor oil. In the hot water process the seeds were crushed in a flour mill and boiled with water in the ratio of 1 : 5 by weight in an open pan and supernatant oil decanted after cooling and filtered. In the case of *chekku* extraction, both powered and non-powdered seeds were crushed separately in two wooden *chekkus* drawn by bullock power. The percentage of extraction and quality of oil was same in both the cases though a saving in time of extraction by 20 per cent. was observed in the case of powdered seeds. In the screw press system the method usually adopted for the extraction of castor oil was followed. The results disclosed that the maximum extraction of 21·5 per cent of oil was recorded in the case of country *chekku* and the cake obtained was soft and relished well by cattle. The hot water process gave 15 per cent. oil and the cake had much of oil in it while the screw press gave hard cake not relished by cattle with an oil extraction of 18·8 per cent. The seed cake analysed five per cent. nitrogen, 1·6 per cent. phosphoric acid and 1·15 per cent. potash. It was tried both as manure and as cattlefeed. Feeding trials of tobacco seed cake with work animals at Guntur and milch cows at Coimbatore disclosed the suitability of the same for replacing other cakes in the feed without any adverse effect on the weight, health or milk yield of the animals. Manurial tests revealed that the cake was as efficient as groundnut cake if applied in sufficient quantities to supply an equal dose of nitrogen. The

oil was found to be free from nicotine or other harmful substances. It could be used for edible purposes as also for burning lamps. It was also found effective as an insecticide on caterpillars and semi-loopers. It formed a good base for the paints and varnishes and was useful in the manufacture of soaps. The production of tobacco seed, oil and cake on a commercial scale however remains yet to be taken up.

Seed multiplication and distribution.—Quality of leaf is of great importance in the valuation of Virginia tobacco and this can be kept up only by the use of pedigree seed of reputed quality. A scheme for the production and distribution of pure seeds of *Harrison Special No.* 9 was started in 1939–40 and operated till 1947. Under this scheme seedlings for the seed-farm area were raised at the Agricultural Research Station, Guntur and supplied to the ryots at contract rates. Roguing of the seed-farms was done under Departmental supervision and the ryots were paid the proportionate value for the number of plants pulled out. The harvesting, threshing and cleaning of the earheads were done at the cost of Government and the growers paid at Rs. 10 per acre for such collection of seed. The following quantities of seeds were produced and sold under this scheme in recent years, viz., 7,071 lb. in 1944–45, 8,976 lb. in 1945–46 and 8,622 lb. in 1946–47 with the result that the departmental seed had become extremely popular in the tract.

Part played by the Agricultural Research Station, Guntur, in Tobacco Research.—The chief centre for tobacco research carried on by the department is the Agricultural Research Station, Guntur, representing the typical blacksoil area of the tract, opened in the year 1922. The introduction of new varieties suitable for cigarette tobacco was the earliest item of work taken up at the station and as a result of large scale trials, varieties Adcock and Harrison Special were found suitable. The next step was the evolution of two high yielding strains, Adcock 13 and HS. 9 as a result of breeding research. In country tobacco strains *T* 16 and *T* 20 were evolved. The Virginia tobacco strain *HS.* 9 has proved to be very popular and it is estimated that it covers nearly 95 per cent. of the area under Virginia type. The manurial tests conducted at this station have given useful results.

The Indian Central Tobacco Committee—Its genesis and contribution.—The trials on a commercial scale to produce cigarette tobacco was first made in the Guntur district by the Indian Leaf Tobacco Development Company. For the past two decades this agency has also been carrying on experimental research on cigarette tobacco and advising growers with regard to crop rotations, cultivation, use of manures, etc. Since 1936, the Indian Council of Agricultural Research had initiated a scheme for co-ordinated research on cigarette tobacco in co-operation with the Indian Agricultural Research Institute, New Delhi. The Tobacco

Research Sub-Station opened at Guntur in the year 1936 has been carrying on research under the above auspices.

Shortly after the imposition of the excise duty on cured tobacco in 1943, the Government of India decided that non-lapsable grant of ten lakhs of rupees per annum be given to the Indian Council of Agricultural Research for the improvement of the production and marketing of tobacco, pending the establishment of a Central Tobacco Committee on an All-India basis. The Indian Central Tobacco Committee was set up in 1945 with functions to assist the development and improvement of the production and marketing of tobacco and its products and all matters incidental thereto. A Central Tobacco Research Station opened in Rajahmundry since then has drawn up a comprehensive programme of work. The Committee has also opened one of its Research Stations at Vedasandur in Madurai district, with the object of growing wrapper tobacco.

BETEL VINE (*Piper Betle*) (*Piperaceae*).

Betel vine is a perennial, dioecious creeper, climbing with the help of adventitious roots produced at the swollen nodes. It is extensively cultivated for the sake of its leaves which are chewed with arecanut. The leaves are ovate, oblong or ovate-cordate, petioled, five to seven ribbed, smooth with an entire margin and acute tip.

The method of cultivation of betel vine varies in different places; the cultivation is also difficult as the crop requires an equable temperature, uniform degree of moisture and much attention. The plant is propagated by cuttings which are grown under the shade of specially constructed sheds of grass, reeds, or mats having a flat roof which admits a diffused light. The plants are trained on live standards grown in parallel rows so that one can easily pass through in between. Sometimes the vines are cultivated under the shade of trees, very often the arecanut palm or other trees specially grown as the standards. In the south, *Sesbania grandiflora* plants are grown in compact blocks to serve as standards.

The channels are dug and filled with water once in four days. The plants begin to yield when nine or ten months old, and thereafter a picking is given every month. The plantation lasts for three years and during the period 5,000 *palogais* of leaves (apalogai contains 2,000 leaves) can be expected per acre.

Betel cultivation was taken up by the department at Vellalur Experimental Station; the Government Agricultural Chemist, Entomologist and Mycologist, investigated the betel vine diseases and the following is the report :—

As early as the year 1911, the attention of the department was drawn to the fact, that the cultivation of betel vine was steadily on the decline in the important betel growing villages in the Noyyal

valley, viz., Singanallur, Vellalur and Sulur owing to the poor returns of the crop. The deterioration of the vines was popularly ascribed to the presence of earthworms in the soil. After some investigation, it was concluded that the deterioration was primarily, if not entirely, due to bad drainage. So persistent was the belief of the ryot in the alleged evil effects of earthworms that the Agricultural department thought it worthwhile to go into the question thoroughly and ascertain the exact role of the earthworms. The betel-vine-station at Vellalur (Coimbatore district) was opened and investigations were started in the year 1924 conjointly by the Government Entomologist, the Government Agricultural Chemist, the Government Mycologist and the Deputy Director of Agriculture, VIII Circle.

Laboratory investigations along with inoculation trials have definitely shown that no specific fungus was directly responsible for the 'deterioration' disease found at the Vellalur station but various fungal organisms invaded the plant, when it was in a condition of low vitality due to other causes and hastened its death. Improving the drainage, by raising the beds on which the vines were planted resulted in improvement of the soil culture and minimised attack by fungi.

The effect of eel worms on the crop was also studied as there was a local belief, that these were responsible for the lowered vitality of the vines, which were found to develop knots or nodules, with colonies of nematode on the roots. Actually neither fungi nor eel worms are responsible for the unhealthy condition of the crop, but the factors responsible for the poor crop were also favourable for the development of fungal organism and for the breeding of eel worms.

So far as can be ascertained by experiments at Vellalur, the prime factor that is responsible for this lowered vitality seems to be bad drainage and this is confirmed by the fact that the low-lying portions of the field showed greater number of casualties than the other portions.

Plants as source of insecticides.

(*Tephrosia vogelii*) (*Leguminosae*).—Seeds of this plant were obtained from the Superintendent of Plantations, Tanganyika Territory in July 1939 and were tried at Coonoor, Kallar and Taliparamba. The seeds germinated and established well at Coonoor and Kallar.

Tephrosia vogelii yields the common fish poison of tropical Africa, and it is also an efficient insecticide as effective as nicotine sulphate. An infusion of the leaves can be used for the purpose.

In February 1941, the Government Entomologist prepared the infusion of the leaves as per the following proportions and tried it on caterpillars and obtained good results. There was 92 per cent mortality of caterpillars.

A water extract of the leaves was prepared at the strength of half a pound of leaves to three gallons of water and to this half an ounce of soap for each gallon of infusion was added. The extract thus prepared was effective, but it was found to be ineffective without the addition of soap.

The seeds of the plant are reported to be very toxic. An infusion of the seeds was prepared using one ounce to one gallon of water and tried against mealy bugs, *Pseudococcus virgatus*, on *Gauzuma tomentosa* with and without the addition of soft soap at one ounce per gallon. The infusion alone caused 32 per cent. mortality in the case of the adults and 26 per cent. in the case of the nymphs, while in combination with soap it caused 33 per cent. and 45 per cent. mortality in the case of the adults and the nymphs respectively.

PYRETHRUM (*Chrysanthemum coccineum*) (*Compositae*).

Pyrethrum—Its cultivation and uses.—Pyrethrum is well-known from early times for the insecticidal properties of its flowers. It is finding increasing use in anti-malarial work all the world over in view of its non-toxic-nature to human beings. The world demand for pyrethrum is now met mostly by Japan and Kenya highlands where it is cultivated extensively. The demand in India is at present met by imports chiefly from the two countries named above. With a view to introducing pyrethrum cultivation in India the Indian Council of Agricultural Research has been supplying pyrethrum seeds to different States. With these seeds attempts were made to grow pyrethrum in Coimbatore, Nilgiris and Yercaud hills in the Madras State. While it did well on the hills it failed to establish itself at Coimbatore. In view of the successful cultivation in the hills, it may be possible to cultivate pyrethrum extensively in the hills and meet the demand in India by local production.

Cultivation.—The plant can be propagated both by seeds and by suckers. Sowing is done preferably in the warm months, i.e., March, in well-prepared beds, the seed rate being half a pound to plant an acre. Seeds take nearly two to three weeks to germinate. Seedlings are fit to be planted out in July, four months after germination; planting is done 18 inches apart each way in a previously prepared field. Subsequent operations consist of weeding and general care. Flowers begin to appear 16 months later and are then plucked at intervals of a week. The ripeness of flowers for harvest is indicated by the flattening of the petals and opening of two or three outer disc florets. The yield of dried flowers is estimated at roughly 400 lb. per acre.

Flowers are destalked and are dried in thin layers for a few days till they become crisp and crumble to the touch. They are then stored in suitable containers to prevent loss of insecticidal property which would otherwise occur.

Cultivation of the pyrethrum was taken up in the Nilgiris, the Shevaroy hills and Kodaikanal on a fairly large scale by the Forest Department. A number of planters had also taken to this crop.

Uses.—The flowers are usually ground to a fine powder and used as a dust against soft bodied insects. Pyrethrum can also be used in sprays with equal advantage. The value of pyrethrum in anti-malarial work is considerable. Kerosene extracts are prepared by soaking a pound of coarsely ground flowers in a gallon of kerosene oil and diluting it with an equal quantity of kerosene after extraction. The extract is then sprayed in any required place against mosquitoes.

Pyrethrum is the chief ingredient of the mosquito coils sold in the market; they are found to act as efficient deterrents against mosquitoes, when burnt.

DERRIS ELLIPTICA (*Leguminosae*).

This is a climber; the leaves are odd-pinnate, long petioled, leaflets nine to 13 inches large, sub-coriaceous, obovate to oblong; branches densely clothed with brown pubescence. Inflorescence is a lax, elongated raceme. The flower has a broad, densely silk calyx, and the corolla is bright red; pod is narrow.

Derris is considered efficacious both as a contact and stomach insecticide. The toxic principle Rotenone is contained only in the roots of the plants which are known to possess not more than four per cent. of Rotenone content at the highest. Derris can be used with advantage both as a dust or in solution as a spray.

Preparation.—The roots are harvested at the end of the 18th to 24th month after planting. Care should be taken to see that the smaller roots are not lost. Harvesting is done by first cutting the stems to the base and then the roots are lifted in a clump with a fork. The roots have to be cleaned well but water should not be used for the purpose. The cleaned roots are cut into bits of one foot length and dried for seven to ten days in the shade till they begin to break when bent. Then they are bundled up and preserved in containers for future use.

Use—(*a*) *As a dust.*—The dried roots are finely pulverized and then mixed with an inert material like wood ash in the proportion of 1 : 6 by weight and then dusted on the foliage infested with caterpillars and plant lice.

(*b*) *In aqueous solution as spray.*—Derris roots can be mashed to a pulp in water and then made up to the required quantity of water in the proportion of one pound to 15 to 20 gallons of water to which two pounds of soap is added to improve the spreading nature of the fluid. It can be sprayed in this proportion with good results for the control of caterpillars, thrips, plant lice, etc.

A few cuttings of *Derris elliptica* were obtained from Mysore and planted in the Insectary compound, at Coimbatore. These throve well and from them, cuttings and layers were raised and distributed among the agricultural stations in the State, at Taliparamba, Nileshwar, and Pilicode in the West Coast; Palur in the East Coast, Hagari in the Ceded Districts and Samalkot in the Circars. The plants came up well. From the experience gained at the Insectary and the Agricultural Stations, and from the ease with which the plant is reported to grow in Travancore it is certain that the plant can be cultivated on a large scale if only enough planting material is available.

STINK GRASS (*Melinis minutiflora*).

Stink grass has been reported to ward off mosquitoes and snakes. To verify the belief an experiment was conducted at Mettupalayam near Coimbatore and it proved that the grass had not got the property of either warding off of mosquitoes or snakes.

OTHER USEFUL PLANTS.

Eriodendron pentandrum.

Kapok (*Malvaceae*).—The fine cotton like fibre known as 'Kapok' is now familiar to everyone from its widespread use as stuffing material. The term 'Kapok' has been used for the product of a number of trees but it should be restricted to the floss of *Ceiba pentandra.* This tree which belongs to the family *Bombacaceae* attains a great size under natural conditions but in cultivation it is usually seen as a slender tree not exceeding 50 feet in height. It has a very characteristic appearance producing horizontal branches arranged in tiers. It sheds its leaves in the dry season. The flowers appear just before or at the same time as the new leaves. The fruit is a more or less oblong capsule about six inches long and two inches in diameter at its greatest width. In ripe pods the hairs are detached from the inner carpellary walls and their separation is very easy.

The chief use of Kapok is for stuffing life-belts, cushions, pillows, mattresses and similar articles. It is well adapted for this purpose on account of its lightness, springy and resilient nature and its non-hygroscopic and non-absorbent characters.

Kapok seed is rich in oil and in many countries where the floss is prepared for local use, the oil is expressed from the seed and employed for cooking and other purposes. In general characters the oil resembles the cotton seed oil. After refining, it can be employed as edible oil and it is also suitable for soap making and other purposes for which cotton seed oil is used. The residual cake left after the expression of the oil forms a fairly good feeding stuff for livestock. It is somewhat inferior to cotton seed cake and it is believed to be used principally as an ingredient in compounded feeds. The cake is also rich in constituents of manurial value.

A suitable climate is the first essential to the successful cultivation of the Kapok trees. Although found in a wild or semi-wild state from sea level up to an altitude of 3,000 or even 4,000 feet and more, the tree gives best yield and quality of fibre when grown at elevations less than 1,500 feet above the sea level. It can withstand slight frost, but low temperatures hinder the growth of the tree and the development of the fibre, and from a commercial point of view cultivation should be attempted only in the tropics or in certain parts of sub-tropical countries. As regards rainfall, the tree flourishes under wide range of conditions. It reaches its greatest size in the tropical rain forests of West Africa, but at the same time owing to its deciduous habit it can resist long periods of drought. The ideal conditions are abundant rainfall during the growing season and a dry period from the time the flowers are setting and until the pods are harvested.

Soil.—A well-drained soil is necessary for the proper growth of Kapok. It flourishes well in a deep, sandy loam. Land infested with white ants should not be used for Kapok, as the tree is very susceptible to the attacks of these insects.

Propagation.—The tree is easily propagated from either seed or cuttings. Plants raised from cuttings come into bearing somewhat earlier, but, on the whole, the general opinion is in favour of propagation by seed. About six pounds of seed should be sufficient to plant up 100 acres. The seed is sown in nurseries sometimes in rows ten inches to twelve inches apart in raised beds or as recommended in the Philippines in "hills" about six inches apart. The nursery must be carefully prepared, the soil manured beforehand, if poor, and kept well weeded. In dry weather watering may be necessary. As soon as the seed has germinated which takes only a few days, the seedlings are shaded until they are about five or six inches high when they must be exposed to the sun. If the plants do not obtain plenty of sunshine, they grow thin and lanky. At this stage the seedlings should be thinned out six inches or nine inches apart. When sown on hills or mounds only one seedling should be allowed to each hill. The young plants grow very quickly and when six to twelve months old they should be transplanted in their permanent site. When grown as a pure crop in plantations, the seedlings should be placed about 18 feet apart. The seedlings when removed from the nursery should be topped and all leaves removed. While lifting the plants, the roots must not be damaged and planting up must be done immediately. If possible, transplanting should be done during rainy weather.

Kapok trees usually begin to bear in three or four years after planting but the yield at first is low. Seven years old trees will yield 350 to 400 pods and ten-year old trees 600 pods or more per year. The yield of cleaned floss from the pods varies somewhat, but on the average, it may be taken that 100 pods will yield a pound of cleaned floss. On this basis an acre planted with 132 trees (18 feet × 18 feet) would yield about 800 lb. of floss.

Little rice (*Chenopodium quinoa*) (*Chenopodiaceae*).—Little rice is claimed to be a food crop which thrives at higher altitudes and which can withstand frost. It is a native of Chile and Peru. It is reported to have higher percentage of protein and fat than cereal grains. It is also considered to be a good green manure crop. A small quantity of seed was obtained from Kenya and tried at the Agricultural Research Station, Nanjanad, with an altitude of 7,200 feet, but no germination was noticed.

Tung oil (*Aleurites fordii*) (*Euphorbiaceae*).—Tung oil tree is a native of China. The seeds yield a drying oil known as Chinese varnish or tung oil and it is also called Chinese Wood oil, as it is used to coat boats and other wood works. It dries within four hours. The tree flowers at the end of May or the beginning of June and the fruits ripen in cold weather. Each fruit has three to five seeds and they contain about 38 per cent. of oil. It is ordinarily expressed by cold pressing.

Uses.—The oil is used as a base in paint manufacture. It is also used as a varnish for lacquer work.

There are five tung oil trees in Sim's Park, Coonoor. Two of the big trees are flowering regularly every year but the fruits are dropping off before they mature. Four plants were sent to the Agricultural Research Station, Taliparamba, for trial, out of which two plants died and two are surviving.

INDIGO (*Indigofera anil 1 Sumatrana*) (*Leguminosæ*).

Summary of the position of the indigo in Madras.—The normal area under indigo in the Madras State was 110,000 acres before 1917. The area decreased in later years consequent on the import of synthetic indigo. In 1913–14 it was as low as 55,000 acres but in 1914–15 there was a return to 71,680 acres, and in 1915–16, 222,000 acres were sown and in 1916–17, 460,000 acres. At present very little natural indigo is manufactured in the State.

When the supplies of synthetic dyes from Germany were cut off due to war, the demand for natural dyes became universal. The Government of India appointed an officer in 1916 with headquarters at Pusa to make investigations of possible improvements in the manufacture and standardization of the indigo dye and the desirability of marketing the natural indigo in a form suited to the requirements of users. The Government of Madras appointed in 1917 Dr. Marsden of the Industries Department to undertake in this State the investigations of the methods of manufacture followed by the ryot and for suggesting improvements in them; for enquiring and, if possible, reducing adulteration and generally to report upon the then existing conditions.

Madras was then the most important indigo producing State next to Bengal. Export of Indigo from Madras, was about 50,000 cwts. per annum valued over a crore of rupees. The chief markets for Madras Indigo were Egypt and Japan, and only some superior qualities were exported to Europe.

The chief indigo growing districts were South Arcot, Cuddapah, Nellore, Guntur, Kurnool, Chingleput, Krishna and Visakhapatnam. The chief indigo markets were in Produatur in Cuddapah district and in Madras City. It was then realized that the produce from the Nellore district and the districts surrounding Madras was the best, being of good average quality and free from adulteration.

The Lankas of the Godavari district yielded a medium quality of indigo while that from the Ceded Districts was very variable in quality. South of Madras the produce was in general of low quality.

Cultivation practices of indigo in the State in vogue in 1916.—Indigo is, in general, sown as a dry crop; but in some localities it is sown on garden and even in the wet lands; the ryots know perfectly well that although the plant grows much more luxuriantly in the latter condition the dye content of the leaf is high in dry land crops. In dry land, the crop is sown mixed with other crops like ragi, mustard and gingelly. The general period of sowing is December-January. The first cutting is taken in about three months, followed at intervals of about two months by the second and the third cuttings. In Nandyal division the seed is taken from the second crop, and the dye from the third crop, while in Godavari the seed is taken from the first crop, and the second cutting is taken for dye manufacture.

Throughout the State only one species, viz., *Indigofera sumatrana* was cultivated. The trials made by the Agricultural Department to grow the Java-Natal variety of indigo proved unsuccessful. The seed which throughout the State was looked upon as the best was that obtained from the Nandyal division of the Kurnool district. The next best was from the Lankas of the Godavari. In a few places seeds obtained from Cawnpore were also sown.

Land intended for indigo was generally manured either by penning sheep or goats or by means of farm-yard manure to the extent of ten cart-loads per acre.

The average yield of a good crop was about nine to ten thousand pounds of green stuff per acre, and the second cutting ten to twelve thousand pounds. About 25–30 lb. of indigo dye is the yield reported to be obtained from 5,000 lb. of leaves. The Saidapet Farm records showed that the crop from one acre, produced 12,000 lb. green stuff and its yield of dye was 50 lb.

Methods of Indigo Dye production and manufacture then prevalent.—The extraction of indigo from the plant is carried out in vats of brick coated with cement, rectangular in shape but in Godavari the steeping vats are cylindrical. The usual capacity of rectangular vats is about 500 to 600 cubic feet, while the cylindrical vats had a capacity of 150 cubic feet. The steeping vats are built at a higher level than the beaters, so that the steeping liquor flows from the former into the latter by gravitation.

Filling.—When ready, the plant is cut about four inches from the ground, tied into bundles and transported in head-loads to the vat where it is stacked (as far as possible) in the shade. Cutting is carried out in the early morning and the filling of the vats may commence at about 10 a.m. or be delayed until early afternoon. The filling is done by opening out the bundles and placing a layer (the shoots lying all in one direction) upon the floor of the vat. Each succeeding layer is placed in the alternate direction until the vat is sufficiently full when light bamboo sticks or mats are placed upon it; poles which reach across the vat are laid upon these, about three feet apart and the whole contents of the vats are then compressed by two heavy blocks of timber which are levered down and held in position by pins passing through holes in the stanchions fixed in the walls of the vat. Water is then run in until it stands just above the level of the plant material.

Steeping.—In three to four hours signs of fermentation are seen, and this goes on increasing until the surface of the water is covered with froth formed by bubbles of escaping gas, and when this froth commences to subside, it is taken as an indication that the fermentation has ended and the steeping liquor is ready to be run off. This may be in 14–16 hours from the time of filling, but the vat is usually drained for beating at daylight the following morning. The steeping vat is then cleaned and prepared for filling with fresh leaf and only then is the beating or æration of the steeping liquor in the next vat proceeded with.

The officers of the Agricultural Department have pointed out, by leaflets and by word of mouth, that delays are not conducive to the production of high quality of indigo, that a steeping of 12 hours under normal conditions is to be preferred, and that all delay in proceeding with the beating process should be avoided as leading to the destruction of the dye.

Beating and boiling.—Indigo blue is produced from the steeping liquor by æration but there are slight variations in different localities in the way in which it is carried out. In South Arcot and around Madras, flat, circular pieces of wood are tied firmly to the end of bamboo sticks about five feet long to form paddles and, standing in the vat in a rough circle the beaters dash the surface liquor against the walls of the vat, or facing towards the centre get a 'Swing' on the water so that the waves meet in the centre and the spray dashes up above their heads. In Guntur and Krishna the beaters gradually move round the vat dragging the face of the paddle through the water with semi-circular sweeps, whilst in Visakhapatnam district the water is dashed against the vat sides and into the centre by sticks to which are fastened short cross-pieces of wood which are vigorously plunged almost horizontally along the surface of the liquid.

Under the influence of the æration, the yellowish green fluorescing liquid rapidly changes in colour to a dull green. A thick

foam is produced and beating is continued until the liquid becomes dark in colour; then a little quantity of the liquor is taken out on a plate and the indigo is seen to be well granulated and separating readily from the water. A little gingelly oil is now sprayed over the surface to kill the foam, and any scum which remains is removed from the surface and the liquor is left to settle. It takes from two to two and a half hours to complete the beating and if all goes well and the indigo separation is good, the topmost plugs of the vat may be opened in about three hours and the surface liquor drained away. To assist settling it is usual in the south of Madras to add a few buckets of clear lime water to the beaten liquor just before the men leave the vat, but elsewhere the general practice is to add an infusion of the bark of the jambolana tree (*Syzigium jambolanum*). The plugs in the well of the beating vat are successively opened until all the clear liquor is drained away or indigo sludge begins to flow. The thin sludge is then transferred by means of buckets to the boiling pan (a conical iron or copper pan set in an earthen fire place) and there boiled over an open fire.

Draining and pressing.—After boiling, the indigo sludge is bucketted on to the draining table—a thick cotton cloth supported upon sticks in a rectangular trough. Until the pores of the cloth are closed, the liquor which filters through is blue in colour and returned to the table until the filtrate is clear. When the boiler has been emptied and no more liquid will drain from the table, the filtering cloth is lifted at the edges and the indigo paste scraped towards the centre, scooped into buckets and taken to the press.

The press box is a wooden frame made of thick, well seasoned planks. It has to withstand considerable pressure; so the ends of the side planks are bolted together by iron bars threaded at the ends of and fitted with nuts. These side planks are perforated with numerous holes and rest upon a board similarly perforated, thus forming a stout box. A cloth being evenly laid in this, the indigo paste from the draining table is transferred to it until the frame is full, when the ends of the cloth are laid evenly over the surface and a board which will pass inside the frame is laid on the top; the press itself consists of strong frame (upon which the press box rests) with two upright threaded iron stanchions passing through a heavy wooden beam. Blocks of wood being placed between this frame and the cover of the press box, nuts working on the stanchions are slowly and evenly turned and the contents of the box are compressed, the water remaining in the paste escaping through the perforations. The pressure is gradually increased until no more liquid can be expressed; then, after some time the press is opened up and the slab of moist indigo is transferred to the cutting table where it is cut by a wire into cubes which are transferred to a drying room and there slowly dried; when dry, they form the indigo cakes of commerce.

Cost of cultivation.—The cost of cultivation for dry land seems to be about Rs. 15 per acre and the yield of leaf therefrom valued at Rs. 30–45 per cutting. The cost of manufacture is from Rs. 10–12 per vat and the yield of dry indigo may be placed at about one Madras maund of 25 lb. per acre, per cutting. With indigo at Rs. 40 per maund the return from seed at about Rs. 18 and the value of 'Seet' or refuse from the steeping plant at Rs. 6 (rupees six), the return works out at Rs. 35–40 per acre. The price of indigo at Rs. 40 per Madras maund in the first instance seems to be about the lowest at which the ordinary ryot here would continue to grow indigo.

Marketing features then in vogue.—The usual practice is that local merchants purchase the produce from the ryot and grade the indigo into various qualities and dispose it off to larger merchants or shippers in centres like Proddatur and Madras. The grading of indigo and price offered is generally determined with reference to the specific gravity, colour, nature of fracture, porosity and the appearance when scratched with fingernail. However, it is only the produce of the Visakhapatnam district which is forwarded direct to the manufacturers in this State who forward it to the agents in Calcutta who ship it to England for sale.

Conclusions and recommendations made.—Dr. Marsden, concludes for reasons stated: (i) that improvement of the indigo plant in this State can only be made by natural selection or by the introduction of some other species capable of yielding a greater amount of colouring material; (ii) that it is certain that the establishment in the vats of a suitable bacterial flora would enormously improve the yield and the quality of the product; (iii) that it has been found that the efficiency of the prevalent process of extraction depends naturally on the nature of the bacteria present in the steeping vats, and (iv) that according as these are favourable or unfavourable, very different yields of indigo are obtained. In different districts in different waters and on different days, variation in the type of the bacteria predominating may occur and account for the variation in yield and quality. The water supplied for vats contains different types of bacteria less efficacious in one case than in the other, for as regards the details of manufacture there is no noticeable difference. One point which may account for the generally reported high yields in Madras is the much smaller capacity of the steeping vats here. A few recommendations made by Dr. Marsden are: (i) The grower should be made to deal direct with the manufacturer and that arrangements may be made to market the produce on contract to be supplied in the quality and form contracted for; (ii) The possibility of getting manufacturers to deliver the produce to a central factory for working up and standardizing and that co-operative schemes should be established in the main indigo centres to meet possible demands from indigo consumers; (iii) That the low average quality of Madras indigo is due to inability to control the manufacture and to the deliberate adulteration with mud in some two or three districts only.

KUDZU VINE (*Pueraria hirsuta—P. thumbergiana*) (*Pueraria phaseoloides*—the tropical Kudzu).

The real Kudzu vine (*Pueraria hirsuta*) is a native of Japan and China. It is perennial with twining stems and large tuberous starchy roots. The vine is noted for the great rapidity of its growth under congenial environment and is a useful cover crop. It is also used as a forage crop and also for ornament and shade. Another allied species, *Pueraria phaseoloides* is met with in India, China and Malaya and this is known by the name Tropical Kudzu.

Kudzu was introduced into the United States of America some time this century and the vine has proved very efficacious in preventing soil erosion and to reclaim highly eroded lands in certain sections of the country. The great potentialities of the vine were recognized only after its introduction to America.

In order to study the possibility of introducing the vine in Madras, trial sowings of both Kudzu and tropical Kudzu were done at a number of research stations in the State in 1946 and 1947. At Coimbatore with an annual precipitation of about 27 inches per annum Kudzu failed to come up while tropical Kudzu came up in pots but not under field conditions. At the Agricultural Research Station, Nanjanad, in the Nilgiris, tropical Kudzu failed completely, whereas Kudzu sometimes grew well, but failed to establish successfully. At the Paddy Breeding Station, Mangalore, and in the sandy soil of the Coconut Research Station, Nileshwar, *Pueraria phaseoloides* was found to come up satisfactorily.

The trials carried out so far appear to show that the real Kudzu is not suited to the conditions obtaining in the State while the tropical Kudzu may be suitable for the conditions obtaining on the West Coast. Further extensive trials are necessary to draw definite conclusions.

RATAN CANE (*Calamus Rotang*) (*Palmaceae*).

This is an extensive, armed climbing plant growing abundantly in the rain forests of Malabar, South Kanara and other places.

The stem of ratan known as ratan cane is used for making baskets, furniture, floor mats, umbrella handles, walking sticks, etc. *Calamus Rotang* and *Calamus viminalis* were tried in Shiyali, Tiruthuraipundi, Mayuram, Aduthurai, Palur and certain other places to see if it can be grown successfully in the plains. They did not make satisfactory growth in any of the places where they were tried.

SINGARAS OR WATER CHESTNUT (*Trapa bispinosa*) (*Onagradacae*).

This is a floating herb found in lakes, tanks and ponds throughout India and Ceylon. The kernel of the fruit is used as an article of food as it contains starch. It may be eaten either raw or cooked. The nuts are considered to be cooling and useful in bilious affections and diarrhoea. It is extensively cultivated in Kashmir.

Season and cultivation.—Generally in the months of January-February when there is sufficient water in the pond, some young growing plants along with submerged stems are introduced in the middle of the pond and allowed to grow. Further care and attention do not seem to be necessary.

In about a year the plants spread out and begin to flower and fruit. The ripe nuts are black in colour and are of a curious form, resembling a bullock's head with two prominent horns (spines). Every year the old plants are to be removed and young ones allowed to spread. The plants yield nuts for about four to five months from January to May, provided there is sufficient water in the ponds. Ripe nuts get separated from the mother plant and sink into the mud at the bottom of the pond. It grows as long as there is water in the pond.

Harvest and yield.—Both ripe and unripe nuts are collected. If the pond is full of water, a small raft or "kattamaran" is used to collect the unripe nuts, and also for diving into the pond to gather the shed ripe nuts which are sweeter. The diver brings out a handful of nuts every time. Since the collection of ripe nuts is a little laborious and time-consuming, harvesting is done once in two to four days according to convenience. No special labour is employed at any time for this work except that of the grower and his people who attend to this work. Each day a few hundreds of nuts are collected depending on the yield and the season. It is difficult to give an exact estimate of yield by weight or number of nuts collected from day to day or for the season and no data are available on this important point to give us an idea regarding the economic aspect of the crop.

Marketing.—The collections of the day of both partially ripe and unripe ones are brought home, boiled and spines and shall removed, the nuts then are sold as whole nuts or cut into pieces for a few annas.

In 1946, ten pounds of seeds of Singara in each of three varieties mentioned below were obtained from the Agricultural Department, Jammu and Kashmir, Srinagar for trial in this State :—

(i) Kang-nuts four spined, large sized, not very delicious.

(ii) Basmat-nuts two spined. The spines are small projections of the shell, thin shelled, delicious, grows satisfactorily in clean and moving water.

(iii) Togar grows well in shallow and muddy waters near the banks of lakes; the fruit is large in size, hard shelled but sweet.

The trials proved unsuccessful since the seeds did not germinate in the centres tried.

CHAPTER 16.

SOILS AND SOIL STUDIES.

Origin of soils, parent rock, climate, morphology, classification, distribution (with map) and important properties of Madras soils—Soil surveys, routine type, of rice growing areas, Tanjore, Guntur, Krishna, Godavari, Periyar, Malabar—Special soil surveys—The several irrigation project areas—The Lower Bhavani, the Tungabhadra, the Cauvery-Mettur, the Toludur, the Gandikota—Area for fruit development in Ceded Districts—Area affected by cyclone in the North-East Madras coast—soil moisture and dry farming practices, work at Kasargod, Nileshwar, Coimbatore and Hagari, the Madras Dry Farming Scheme and summary of experiments achieved—Soil erosion, magnitude, factors affecting, control methods, work at Hagari, propaganda for anti-erosion methods, the Madras Soil Conservation Scheme—Alkali lands, extent in Madras, early attempts at reclamation, sulphur and gypsum treatments, alkali reclamation under the Kattalai High level channel, Tiruchirappalli district, reclamation under dry conditions, natural reclamation—Soil organic matter and its decomposition, humus formation, .the carbon-nitrogen ratio, green manure decomposition, wet land conditions, nitrification studies, decomposition of molasses—Soil conditions as affected by cultural and manuring practices, the cholam effect, the betelvine effect, earthworms and soil fertility, soil studies of a fundamental nature, the need for research on soils, study on black cotton soil and the cause of its colour, origin of soils, Geo-chemistry of Madras Deccan and of Coimbatore district soils—Soil profile studies profiles of the several Agricultural Research Stations, classification of Madras soils on profile basis—Studies of a miscellaneous nature, the permanent manurial plots at Coimbatore, examination and standardization of analytical methods, routine advisory work—Conclusion.

Introduction.—Soil is the basis of all human prosperity, for, without soil no vegetation can survive much less any agriculture. As such it is essential in any scheme of agricultural betterment to have a proper understanding of the soil as a means of improving crop production. In Madras even from the inception of the Agricultural Department soil studies had been recognized as an essential aspect of agricultural research and the Agricultural Chemistry Section has been engaged on this aspect for the past fifty years or so. An account is given in this chapter of the work done in the Department on the varied aspects of soil research, ranging from fundamental investigations on soil formation and classification, to intensive studies of special problems of immediate practical application like, for example, the Tungabhadra soil survey and agronomic experiments at Siruguppa to decide the question whether black soils could be irrigated without bad effects afterwards.

The layman's concept of soil as something dead and inert is a widespread one, but nonetheless erroneous for that. In the words of the great Swedish Chemist Berzelius " Soil is the chemical laboratory of nature, wherein various chemical decompositions and reactions take place in a hidden manner." From the physical point of view, soil is a medium for plant growth, emphasising the mechanical support it gives to plants. Others refer to it as the site for numerous types of microorganisms. Thus the chemical, physical and bacteriological aspects are all involved in the complete definition of a soil concept.

Origin of soils.—The rocks and mineral that form the earth's crust are the parent material for the origin of all soils. Hence agricultural geology is an essential branch of study for the soil scientist, to enable him to understand the derivation of different soil types from different parent material. Climate is another very potent factor which is equally important in soil formation, and as revealed by the studies of Russian pedologists, even the same or similar types of parent rocks, when weathered under different climatic conditions may give rise to different soil profiles. It is now recognized that the soil is a function of rock, climate and time, in other words different sets of climatic conditions operating through a suffiiently long period of time on different parent rock materials result in the different types of soils in the world. Based upon this concept, the following definition of soil due to Marbut the great American Pedologist is the one generally accepted.

The soil consists of the outer layers of the earth's crust usually unconsolidated ranging from a mere film, in thickness to a maximum of ten feet or more which differs from the material beneath it (also usually unconsolidated) in colour, texture, structure, physical constitution, chemical composition, biological characteristics and in reaction and morphology.

Pedology is the study of soil and as in all fundamental sciences the morphological or descriptive phase is the first phase in soil studies also and the soil profile is the unit of study in all soil research. The soil profile is a vertical section of the soil down to the parent rock, showing the different " horizons " that constitute it. There are generally three horizons in all well developed and mature soils known as the " A " horizon or the real soil region, the ' B ' horizon consisting of the weathered rock below and then the ' C ' horizon the unweathered parent rock beneath. In some soils the ' B ' horizon may be absent, i.e., the soil is found over the rocky substratum without any middle zone of weathered rock. This indicates that the soil should have been transported from elsewhere and was not formed in the place it is seen. The soil profile is thus a virtual autobiagraphy of the soil, a study of which enables the trained worker to trace the history of soil-formation processes, the climatic conditions that were operative and the time that should have elapsed. Soil profile studies also help in tracing the relationship in soils found in different countries and regions of the world and in classifying them and have been the basis on which

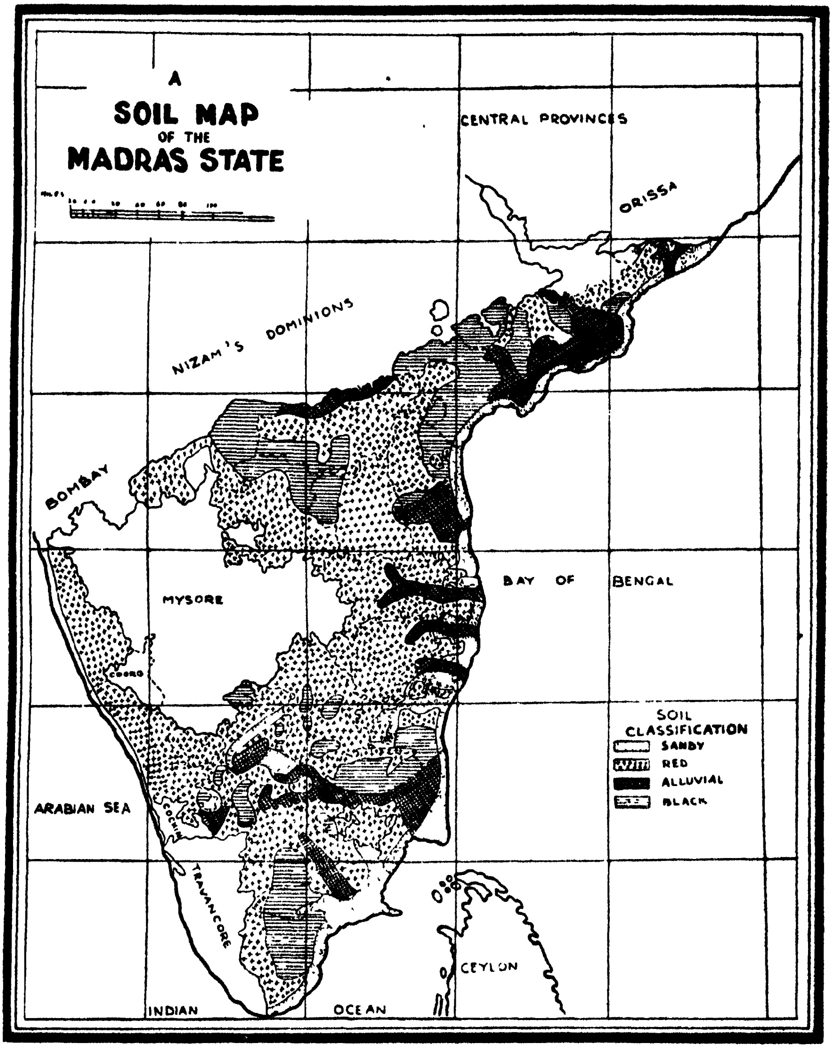

Plate 90. **P. 692**

the Russian theory that the geographic distribution of soils follows the climatic zones, has been based.

Soils of the Madras State.—The State extends from Visakhapatnam in the north (Lat.19 N) to Cape Comorin in the south (Lat. 8 N) and from 74 East Longitude to 86 East Longitude in the east to west direction. The portion from 19 North to 16 North Latitude is a coastal strip extending for about 100 miles inland. In the northern part is a straggling range of low mountains called the Eastern Ghats, and south of this come the great deltas of the Godavari and Krishna. To the south of these deltas is a narrow coastal strip, with broken hilly country to the west and then comes the Cauvery delta. The West Coast of the State is a narrow coastal strip with high mountains known as the Western Ghats often coming within a few miles of the sea. The interior of the State is a plateau ranging from a height of 1,500 feet above sea level in the west shelving towards the Bay of Bengal in the east. The main river systems flow from west to east, while a few short hill streams on the West Coast flow from the Western Ghats into the Arabian Sea on the west.

Climate.—Climatologically, the State can be divided into four zones. (1) The West Coast strip and adjacent mountainous region, with an annual rainfall ranging from 75 to 150 inches, received mostly during the South-west monsoon. (2) The North-east Coast which enjoys both the monsoons and has a rainfall of 40 to 70 inches per annum. (3) The South-east Coast which gets its rains during the retreating monsoon, averaging about 30 to 50 inches per annum and (4) the Central Plateau which is generally dry and semi-arid, with a rainfall of 20 to 30 inches.

Geology.—The oldest and most extensive geological formation in Madras are granites and gneisses of the Archaean period These can be broadly subdivided as (*a*) the younger granites and granitoid gneisses and (*b*) the older gneisses which are schistose in some places. These vary very much in minerological and chemical composition, as the felspars in these rocks may be of alkali, lime or soda lime groups. The other minerals may be muscovite, biotite, hornblende and augite. The accessory mineral may be garnet, epidote, apatite, and magnatite. Occasionally corundum. tourmaline, actinolite, ilmenite and rutile are also met with.

It is also quite common to find granites and gneisses of different minerological composition occurring inter-mixed within a small area.

The Charnockites are characterised by the presence of hypersthene or enstatitie an dalso contain garnets. They occur mostly on the Nilgiris and in parts of Salem and Coimbatore districts.

The Khondalites are similar to the charnockites but occur in the Northern Circars area.

The Dharwars.—These occur in small and long bands in the Anantapur, Bellary, Chittoor and Nellore districts. The main

rocks are banded quartzites hæmatities, hornblended schists, mica schists and traps.

The Cuddapah-Kurnool formations.—These are found in parts of Cuddapah, Kurnool, Anantapur and Guntur districts. The main rocks are slates, shales, sandstones, limestones and quartzites. In the lower Cuddapah formations, contemporaneous trap and dykes of silts are common.

The Gondwanas occur as small patches along the coast between Visakhapatnam and Tanjore and near Rajahmundry. The main rocks are grits, sandstones, shales and limestones.

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Cuddalore formations are found along the coast in some places and are composed of loose textured sandstones and pebble beds, sands and clays.

Laterites.—These are of two types (*a*) the high level laterites and (*b*) the low level laterites found below 2000 altitudes. The latter type occurs along the West Coast as patches and the high level laterites are found on the Western Ghats, the Nilgiris and some of the other high mountains in Madras.

Recent.—In addition to these, along the coast there are also alluviums of marine orgin and the major river deltas. Thus it will be seen that though the geology is uniform, there is diversity in geography and climatology. Climate has played a very important part in the weathering of soil of different types. The mean temperatures are uniformly high with little local variations. The hottest zone is the Central Plateau, with a long, dry summer and a cool winter. The coastal areas have moderate temperatures and a moist atmosphere allthrough the year. Rainfall is another climatological factor that has had an important role in the development of distinct soil profits. A popular classification of Madras soils is given below based upon the studies carried out chiefly at Coimbatore in the Agricultural Chemistry section.

Classification.—A systematic study of the soils of Madras was started in 1931 utilizing the soil samples gathered from different Agricultural Research Stations under the control of the Department of Agriculture. These stations are located in different typical regions and have each a distinct soil type. Thus Koilpatti in Tirunelveli district, Hagari and Siruguppa in Bellary, Nandyal in Kurnool, and Lam Farm in Guntur district are all situated in black soil areas. Samalkota and Maruteru in Godavari district and Aduthurai in Tanjore are in deltaic alluvial areas. Taliparamba and Pattambi in Malabar are in a laterite area while Kodur in Cuddapah district is in a red soil area derived from quartzite rocks. Anakapalle in the northern extreme is typical of the garden land soil of Visakhapatnam. Mention may also be made incidentally of the Central Farm, Coimbatore, where not only black and

red soils but also mixed soils are found to occur within a small area of about one square mile.

From such a representative set of soils a large number of samples was collected with full descriptions of the soil profiles in every case. These samples were subjected to a complete analysis including the chemical composition, mechanical texture, exchangeable bases, analysis of clay minerals and the silica sesquioxide ratio. The data thus accumulated have enabled a classification of Madras soils into the following groups :—

(1) The red soils
(2) The black soils
(3) The coastal alluvium
(4) The delta soils
(5) The laterite soils
(6) Mixed soils
(7) Organic or forest soils.

(*See* Map showing distribution of soil types.)

Types one, three and five are predominantly red, reddish, or brown in colour, while types two and four are dark-coloured popularly terms as black.

Red soils occur over a large area of the State and may be said to be the common type. They occur in all sorts of situations ranging from hill slopes to deep valleys in various parts of the State. They are characterised by a relatively low content of silica of about 40 per cent, low content of lime and magnesia of less than one per cent and a high content of iron and alumina of 40 per cent or more. They are distributed all over the State either in large stretches or in isolated pockets in the midst of black soil areas.

Coastal alluviums and laterito soils are also red or reddish brown in colour but are different from type one red soil both in derivation and in composition.

Black soils occupy for the most part the Central Plateau of the Peninsula over extensive areas of 3,000 square miles and more with scattered occurrences in less conspicuous areas. Black soils are found also in Guntur-Ongole and various places on the East Coast. They occur in the far south in Tirunelveli and Ramanathapuram districts as well. The characteristic feature of black soils are a high contents of silica of 50–54 per cent. high lime and magnesia and low iron and alumina.

Type four, delta soils occur mainly in the deltas of the two great rivers Godavari and Krishna and of the Cauvery delta. Type five, the laterite soils, occur mainly on the West Coast and in scattered areas on the East Coast and on some of the hillocks in the southern region. They too are red in colour but differ in composition and properties from the true red soils. They are formed as a rule under conditions of copious rainfall as in the West Coast and as a result the leaching out of soluble bases has gone to excessive limits so that the surface layer is the exposed

'B' horizon and the 'A' horizon in these soils is found below the 'B' horizon having infiltered from above. Laterite soils have only 35 per cent *silica* and are also poor in bases especially potash, lime and magnesia though they are rich in iron and alumina with nearly 50 per cent.

Black soils have a very high base exchange capacity. Red soils have a lesser exchange capacity with a tendency to increase with depth. Laterite soils have the lowest exchange capacity with only about ten milli-equivalents as against 25 in red soils and 50 in black soils. The exchangeable calcium is also very low in laterites being less than one and show a decrease with depth.

The silica sesquioxide ratio showed similar characteristic differences between the three main soil types. The black soils had value ranging from three to four, red soils from two to two and a half while the laterite soils had values less than 1·5 or even less than 1·0 indicating that they have undergone the maximum degree of leaching. Hydrogen on concentrations too were different with black soils on the alkaline side with p.H. values of over 8·0; the red soils had values from 7·0 to 8·0 while the laterite soils were very acidic with p.H. value as low as 4·0 and 5.0

In general red soils and aluvial soilsc are fertile as they occur in zones where climatic conditions are favourable. Black soils on the other hand are met with chiefly in semi arid regions as in the Central plateau and on account of the fact that cotton is the most important and commonest crop on these soils they are usually known as black cotton soils.

The laterite soils though not intrinsically very fertile ae able to support a good vegetation on account of the copious rains that are received on laterite areas. The tabular statement given summarize the main physical and chemical characteristics of the various soil types in the State of Madas. (Vide page 188.)

From the statement and soil map it will be seen that the soils of the Madras State are very heterogenous-climate, geography and geological formations have all contributed to this heterogeneity so that no uniform programme of manuring of soil amendment can be laid down as applicable to all localities. Each problem of soil management and soil improvement has therefore to be studied in relation to the particular set of local conditions, before a suitable solution can be arrived at. This is what the Agricultural Chemistry section is doing at Coimbatore. The work done in this section is outlined below under the following heads :—

(1) Soil surveys.
(2) Soil moisture and dry farming practices.
(3) Soil erosion control.
(4) Soil organic matter.
(5) Soil conditions as affected by cropping.
(6) Soil studies of a fundamental nature.
(7) Soil profile studies.
(8) Miscellaneous soil studies.

(1) Soil Surveys.

The purpose of a soil survey is to secure all the information necessay to put the land to the best use in cop poduction. It should thus provide all the data on soil quality, how much plant food it contains, whether the amounts are adequate or whether manuring is necessary, the drainage facilities available in the tract and the susceptibility to soil erosion.

A soil survey is done first in the field and later completed in the chemical laboratory by analysing the soil samples and mapping out the analytical results for easy reference. The field work consists of a traverse of the region, digging pits at intervals representative of the tract and collecting samples of the soil. Samples from successive depths usually a foot each are collected down to the parent rock and separately bagged and labelled. A full description of the soil profile and the several horizons is recorded on the spot at each of the profile pits dug. Notes on the topography, the depth of the water table, the predominant vegetation of the tract and other relevant particulars are also included in the report. Where the area to be thus surveyed is extensive, a large staff of trained workers is necessary since the survey and collection of samples have to be completed within a short period during the fallow period in the rainless season so that rains might not hamper the survey work and the farmer's work on his fields too is not hindered.

Types of soil survey.—Surveys are in general of two types (*a*) Routine surveys of different tracts to study the requirements of the cropping in vogue and (*b*) special surveys to solve specific problems or to assess the future potentialities of specific tracts or regions. Any large scale irrigation project is usually preceded by a special soil survey. Both these types of surveys have been conducted by the Madras Department of Agriculture. Routine surveys were done on the deltaic and other rice-growing areas in the State as in the Godavari, Krishna and Tanjore deltas, the Periyar system in Madurai and the rice-areas in Malabar. No profile pits were dug in these surveys, the surface and sub-soils alone being sampled and analysed since the object of the survey was merely to ascertain if the soils in those areas were adequately supplied with nitrogen, phosphorus and potash for growing satisfactory crops of rice.

A soil survey of the Tanjore Delta—(1912 *to* 1913).—Extensive tours were made all over the district in 1912 and 1913 and 134 samples of soil were collected. At headquarters the samples for chemical analysis were reduced to 91 as some samples had been taken at places too near together or were representative of only small isolated areas differing greatly from the general character of the delta soils. These 91 samples were analysed for the chief plant food elements, nitrogen, phosphorus, potassium, lime and magnesia and the results were mapped out showing the places from where the samples were taken and the percentages of the different ingredients and their ranges denoted in different colours for easy reference.

Physical and Chemical characteristics of soil types in Madras State.

Type number.	*Colour.*	*Physical properties.*			*Chemical properties.*					$\frac{S\,10_2}{R_2O}$ *Ratio.*
		Texture.	*Water holding capacity.*	*Porosity.*	*Content of nutrients.* N	P_2O_5	K_2O	*Humus.*	*pH.*	
I Red soil ..	Red to Reddish brown.	Loams or sand loams ; variable.	Fair ..	Good ..	+	+	+	+	5·0 to 7·0	2·0 to 2·5
II Black soil ..	Black or dark in colour.	Usually heavy clay soil.	Very good.	Poor ..	—	+	+	—	8·5 to 9·5	3 to 3·5
III Coastal alluvium.	Brown or reddish brown.	Variable from sandy to sandy loams or loams.	Fair ..	Good ..	±	+	+	±	6·0 to 7·0	2·5 to 3·0
IV Delta soil ..	Variable mostly dark like II.	Mostly clay or silt loams rarely sandy loams.	Very good.	Fair ..	+	+	+	+	7·0 to 8·5	2·5 to 3·0
V Laterite soil ..	Red or reddish brown.	Sandy loams or loams.	Poor ..	Very good.	—	—	±	..	4·0 to 6·0	1 to 2

\+ Fully supplied with plant nutrients.

— Lacking in the particular plant food element.

± Some portions well supplied, some not

pH > 8·0 tends to become alkaline.
< 7·0 neutral or acidic.

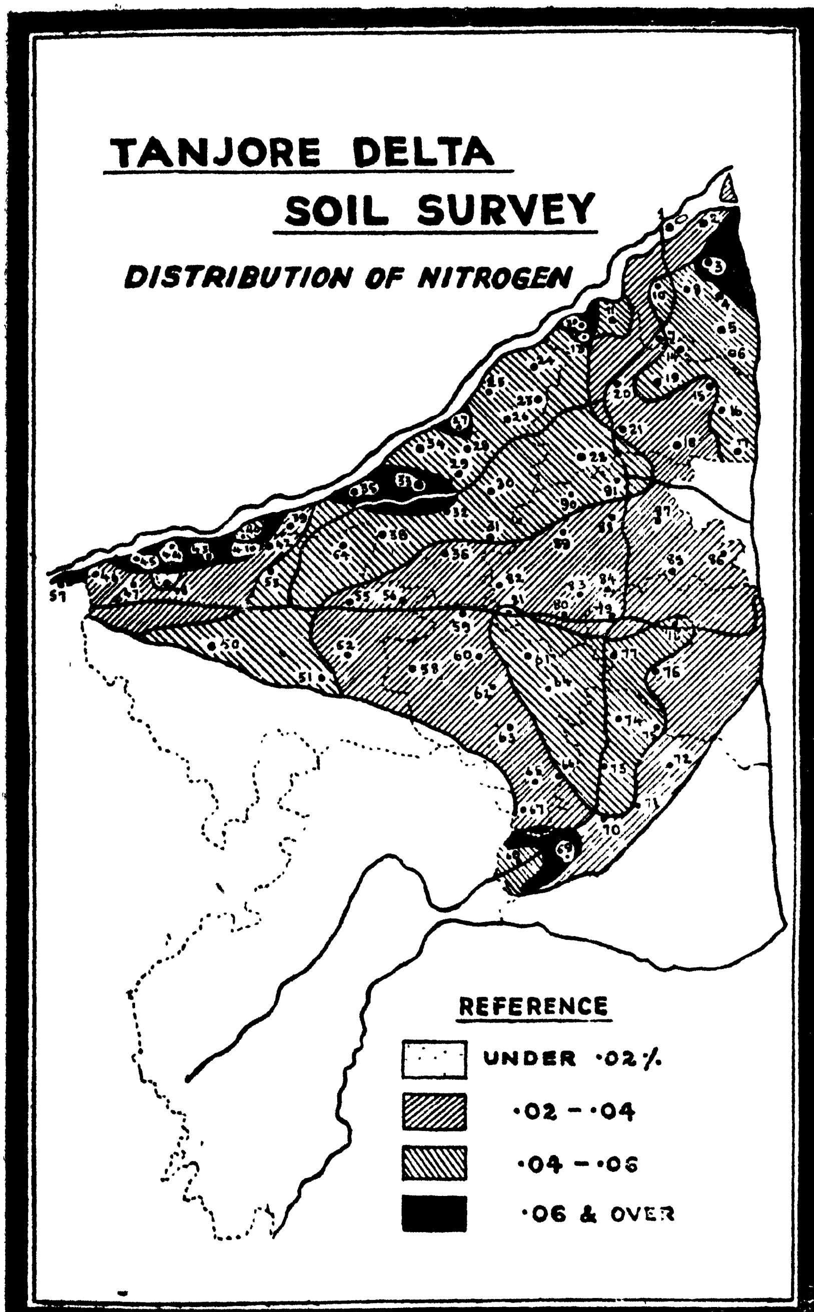

TANJORE DELTA
SOIL SURVEY
DISTRIBUTION OF NITROGEN
REFERENCE
UNDER ·02 %
·02 – ·04
·04 – ·06
·06 & OVER

Plate 91.

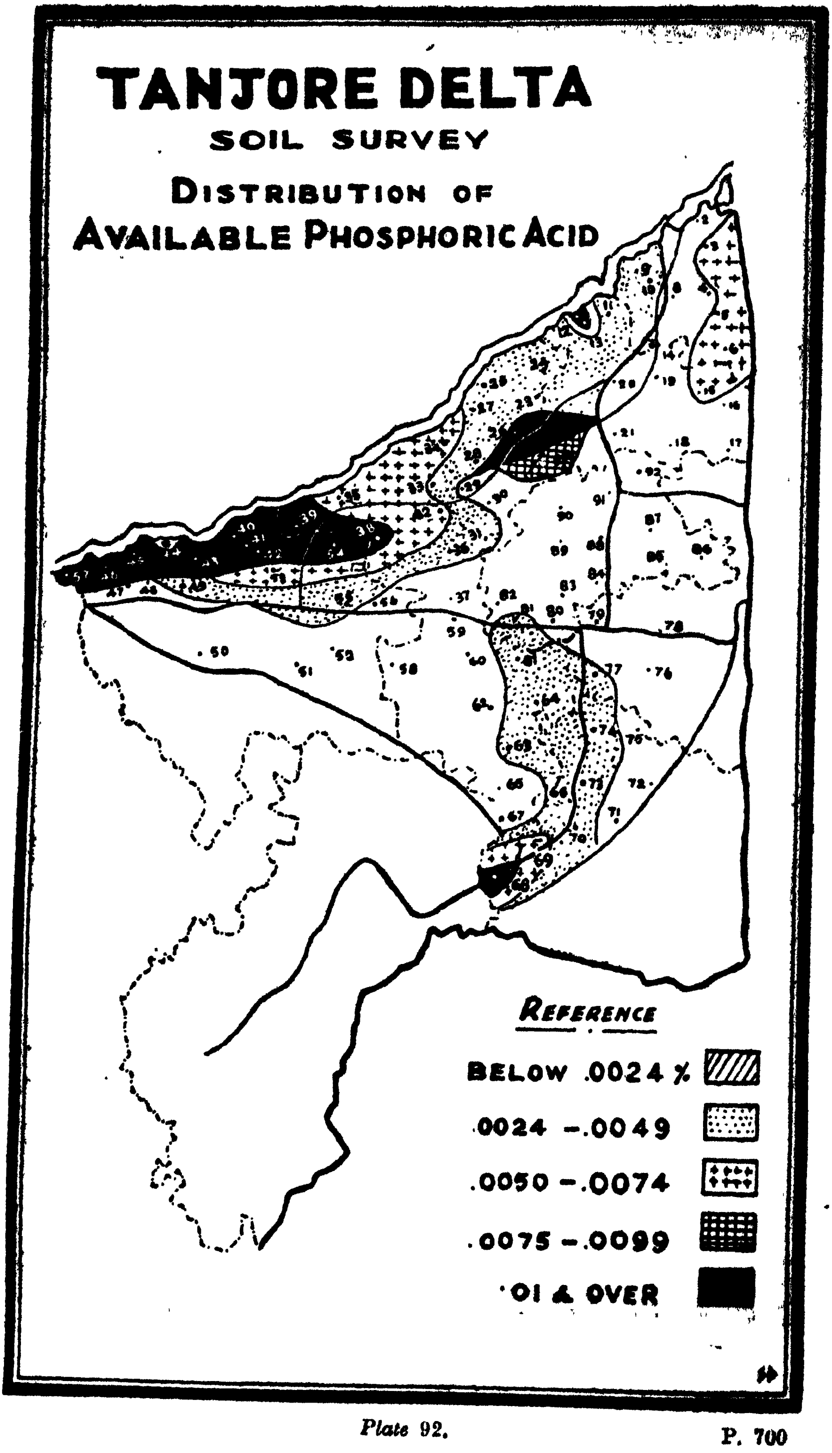

TANJORE DELTA
SOIL SURVEY
DISTRIBUTION OF
AVAILABLE PHOSPHORIC ACID
REFERENCE
BELOW .0024 %
.0024 -.0049
.0050 -.0074
.0075 -.0099
·01 & OVER

Plate 92.

Before acquainting ourselves with the conclusions drawn from the maps, a note of explanation about the different constituents and their significance may be necessary. Nitrogen, phosphorus and potassium are the three essential plant food elements. In reporting the amounts of these found in a soil, the analyst reports the amount of nitrogen as such, but potassium and phosphorus as their oxides —called potash and phosphoric acid. Again, all the nitrogen in a soil is supposed to be sooner or later available for the plants, and hence this constituent is merely reported as the total amount present. As regards potash and phosphoric acid, it is known that only that portion which is soluble in water is immediately available for plants, while a considerable portion may be insoluble and unavailable. The total amount of phosphoric acid and potash in a soil is of less importance than the available values, so far as the immediate needs of the plant are concerned, but the non-available constituents are of importance from another point of view, as they gradually become available as time goes on, and thus constitute what may be looked upon as the dormant plant food in a soil. The soil analyst, therefore, reports both the total and available quantities of these constituents in his analysis of the soil. Two other constituents, lime and magnesia are also determined: these are not essential as plant food, but are important in other ways to the soil --as bases which are needed to correct acidity developing in wet land condtions.

The map showing the distribution of nitrogen in the delta showed that practically the whole of the delta contains less than 0·06 per cent (a low figure) and that about half the delta contains even less than 0·04 per cent. Generally speaking, the richer lands lie among the bank of Coleroon river. The fertility of the soil depends to a very large extent on the most important plant food— nitrogen, and the survey indicated the whole of the delta to be deficient in this nutrient.

The maps for total phosphoric acid and total potash showed that the Tanjore delta soils contain nearly ten times as much potash as phosphoric acid; the richest soils are those along the Coleroon river, while the poorer soils are found in the tract of country running from dry lands of the south to the centre of the delta.

The map showing distribution of available phosphoric acid showed clearly, that the only soils which contain over 0·01 per cent of available phosphoric acid (the limiting value) and which therefore do not require phosphatic manuring, are those in close proximity to the Coleroon river in the Tanjore district and extending into Papanasam taluk. This tract is very circumscribed and constitutes only a small portion of the delta. Small isolated patches of soil rich in phosphoric acid are found on the western side of Mayuram taluk and there is another small area towards the south-western extermity of Tiruturai taluk. Apart from these, the remainder of the Tanjore delta consists of soil which are very deficient in available phosphoric acid.

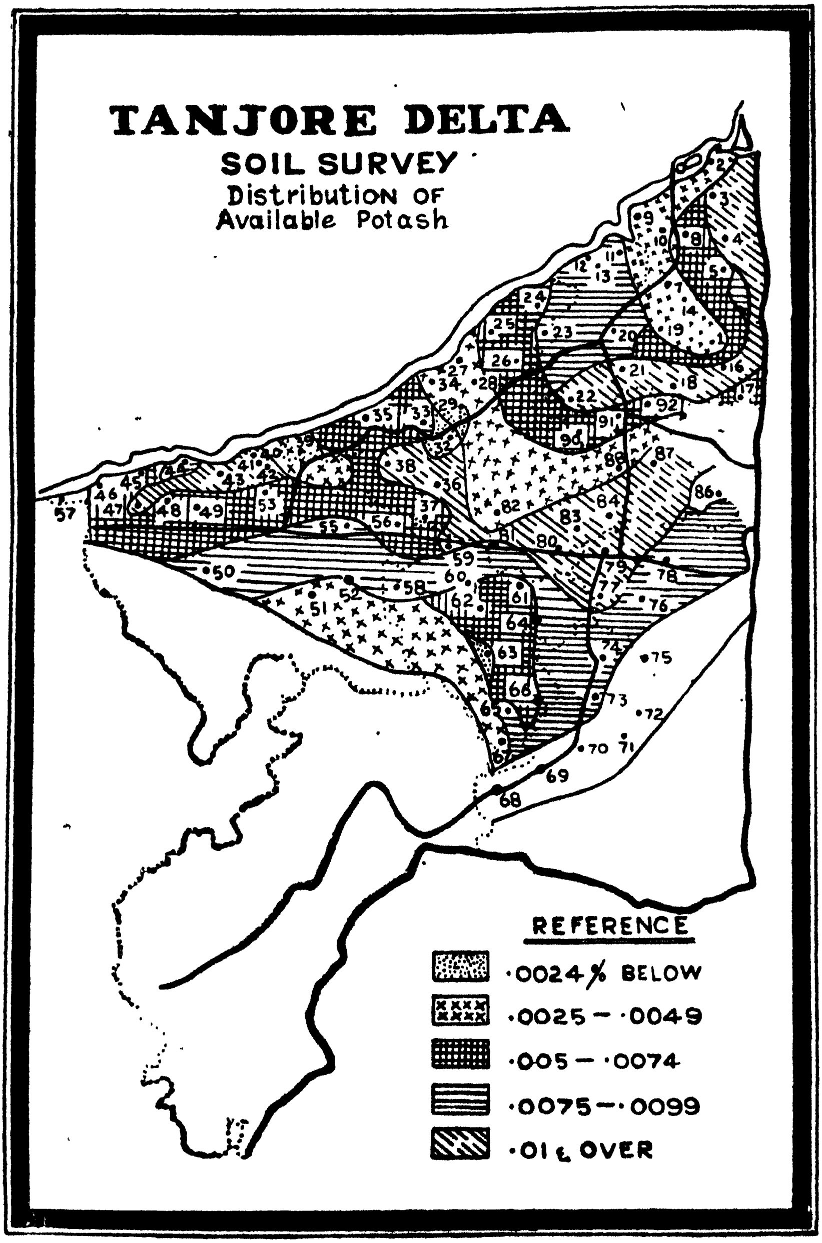
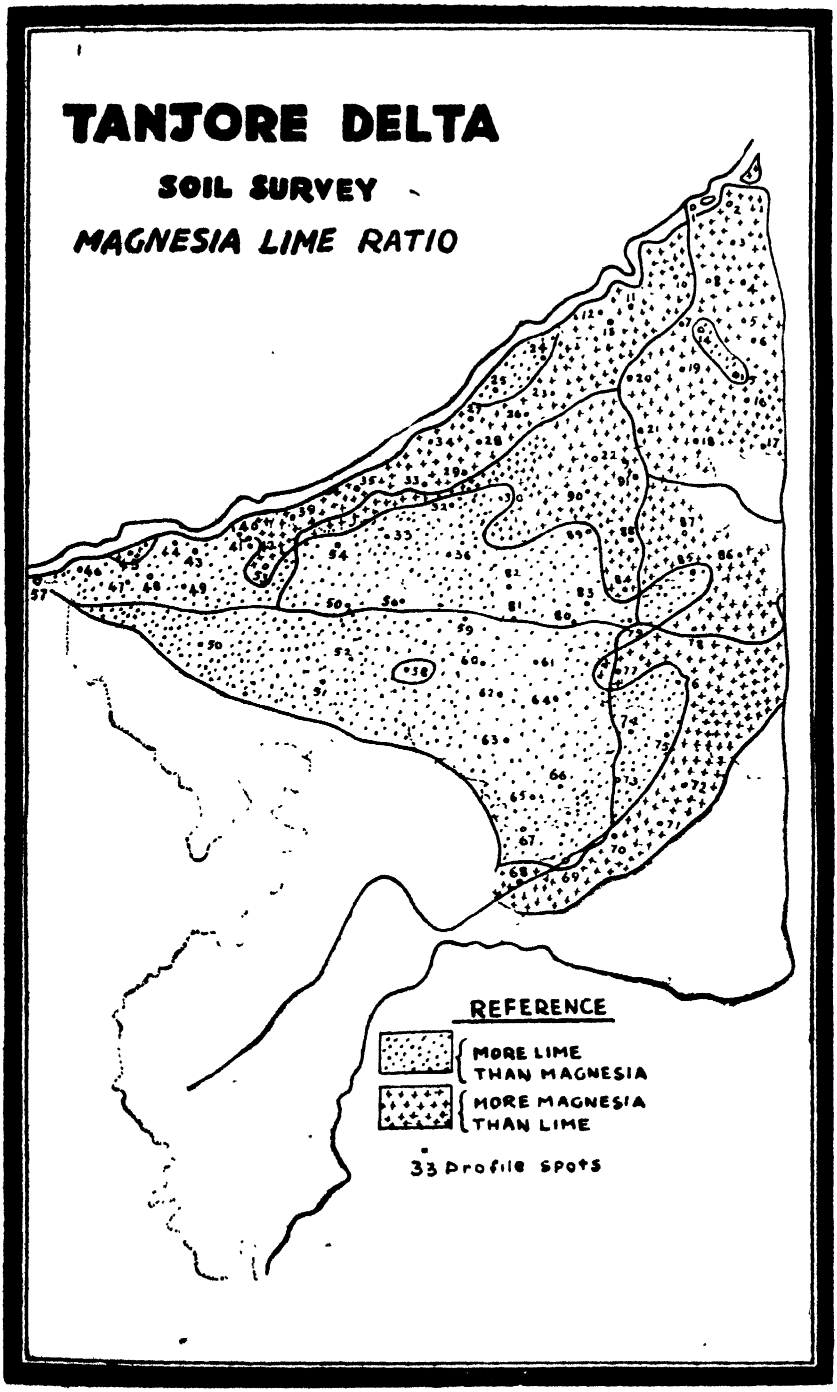

TANJORE DELTA
SOIL SURVEY
Distribution of Available Potash
REFERENCE
·0024% BELOW
·0025 – ·0049
·005 – ·0074
·0075 – ·0099
·01 & OVER

Plate 93.



TANJORE DELTA
SOIL SURVEY
MAGNESIA LIME RATIO
REFERENCE
MORE LIME THAN MAGNESIA
MORE MAGNESIA THAN LIME
33 Profile spots

Plate 94.

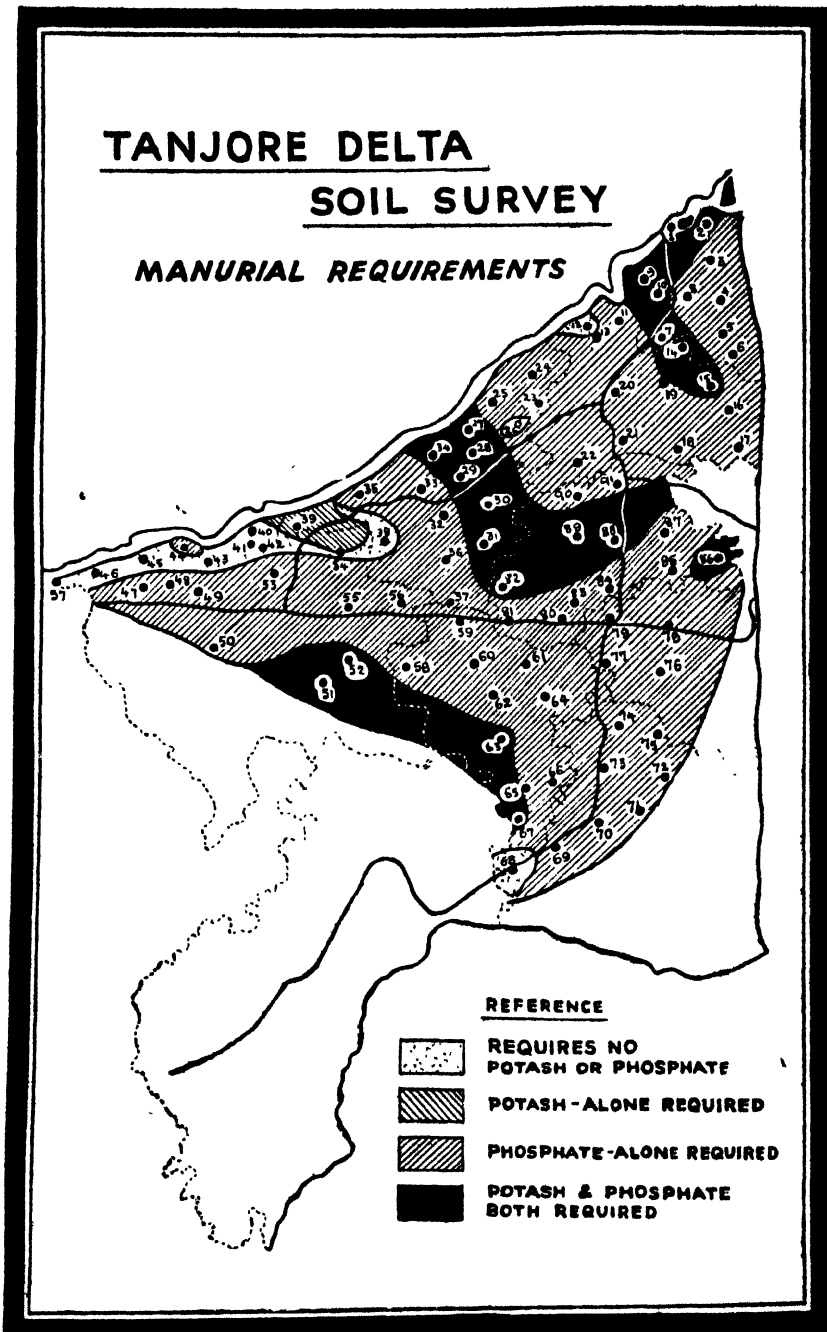

TANJORE DELTA
SOIL SURVEY
MANURIAL REQUIREMENTS
REFERENCE
REQUIRES NO POTASH OR PHOSPHATE
POTASH - ALONE REQUIRED
PHOSPHATE - ALONE REQUIRED
POTASH & PHOSPHATE BOTH REQUIRED

Plate 95₃

The available potash map, showed (taking 0·05 per cent as the minimum value) that the greater part of the delta is well-supplied with this plant food. More than 70 out of 91 samples examined have adequate supplies and are not in need of potassic manuring. The deficient areas are the western portion of Shiyali taluk, a strip of land running across the delta through the Kumbakonam and Nannilam taluks, that portion of Tanjore and Mannargudi taluks bordering on the dry lands, and a small portion of Papanasam taluk adjacent to the river.

The lime-magnesia map of the delta showed clearly that the delta is divided into two clearly marked areas, the northern having an excess of magnesia over lime, and the southern having an excess of lime over magnesia.

Soil surveys of Guntur, Krishna and Godavari Deltas.—In a manner similar to that of the Tanjore delta, soil surveys were done in the Guntur delta (1914), the Krishna delta (1916), and the Godavari delta (1919). The samples drawn and examined from these three areas were 111, 138, 69 respectively. After analysis, the results were mapped out, as in the case of the Tanjore delta. It could be seen from the maps, that as regards nitrogen, Guntur was less but Krishna and Godavari were more than in the Tanjore delta. As regards phosphoric acid and potash, all the three deltas had a higher content than the Tanjore, although, there were certain localities, where the need for phosphoric acid was indicated. Incidentally, it was noted that the silts of the Krishna and Godavari rivers were richer in lime, magnesia, potash and phosphoric acid than the Cauvery silt. The difference in composition of the rock formations of the two tracts through which these rivers flow and the greater flow in the Krishna and the Godavari are probably responsible for this.

Summing up the results of these four surveys, Tanjore, Guntur, Krishna and Godavari, the soils of all the four areas are poor in organic matter and nitrogen and the low amount of this ingredient may well be the limiting factor for crop production. Phosphate deficiency also has to be made up but the position is not so serious as in nitrogen. As regards potash, lime, and magnesia, the soils are adequately supplied and one need not apprehend danger from any shortage of these ingredients.

Considering that these deltas are the granaries of our State, the need for intensive manuring of nitrogen and phosphoric acid cannot be overemphasised. In fact, as a result of the information obtained by these surveys, advice has been given to ryots of the deltas, on the need for supplying nitrogen in the shape of green manures, oil cakes, bonemeal and ammonium sulphate. Many of the experiments laid out in the several Research Stations of the deltas, on the effect of nitrogenous manures on paddy, have been based on the results of the soil surveys. Thus these surveys are helpful in designing experiments in Research Stations, on the

findings of which proper advice could be given to ryots to improve the fertility of their lands.

The Periyar tract.—The area surveyed consisted roughly of a large triangular tract lying between the main Periyar channel and the Vaigai river. The Periyar system derives its water-supply from a lake formed by a dam across the Periyar river which previously flowed from the hills on the West Coast into the Arabian sea. The water is now led in the opposite direction into the Suraliyar river, coming from the Cumbum valley, which in turn joins the Vaigai river flowing in a south-easterly direction into the Bay of Bengal. The Vaigai is dammed by the Perenai anicut and the main Periyar channel takes off from this anicut and runs generally in an easterly direction, irrigating by means of a series of sub-channels, portions of the taluks of Nilakottai, Madurai and Melur in Madurai district. This tract has long been under cultivation, using water from the tanks with which it is liberally supplied. Many of the tanks in the western portion derived their water from the Vaigai river, but those in the north and east were rainfed and the supply was therefore precarious. Since the advent of the Peripar project, however, these tanks receive sufficient water to provide for two crops in the two taluks first mentioned and at least one in Melur taluk. The land adjoining the Vaigai river at the western end of the tract has always been well cultivated and has a reputation for fertility. On the other hand the eastern portion of the Periyar project, however, these tatnks received sufficient water nel have been under paddy cultivation only since the Periyar supply began. In other words, there has been a large conversion of dry land into wet lands, consequent on the assured supply of water.

The Periyar channel has twelve main distributaries which discharge into the tanks aforementioned: and it is from there, that water is taken on to the fields; but sometimes water is led directly into the fields by sluices, from the main channel or its distributaries.

The survey of this tract was done during the summer of 1919 and 67 typical samples from land under rice cultivation were collected. Analytical examination in the laboratory showed that the Periyar tract differed considerably from the delta areas previously surveyed. The salient features are given below :—

The nitrogen conent of the Periyar tract is generally satisfactory, nearly 45 out of 67 samples examined having over 0·069 per cent and of these 45 samples, in more than 20, the amount exceeded 0·1 per cent of nitrogen, a value quite good enough for paddy soils. The area is therefore well supplied with nitrogen. The lime magnesia is however unsatisfactory throughout the tract, magnesia being generally in excess. · As regards potash and phosphoric acid, the position is similar to the delta areas, but the supply of phosphoric acid, total and available, is inadequate and with the exception of a strip of land bordering on the Vaigai river

and hence receiving silt, practically the whole area is urgently in need of phosphatic manures.

In its origin and subsequent treatment including conversion of dry into wet land, the Periyar tract differs from the deltaic areas of the State. Much of the old paddy land in the district had a reputation for alkalinity. This defect has, except in a few localities, been very largely rectified by (1) the application of fresh soil in very large quantities, a practice very common in the tract, (2) the use of municipal rubbish and (3) the extensive use of green manuring, more than in other tracts. In these practices, especially green manuring which has been encouraged by the Agricultural Department's activities and which is assisted by the proximity to forest areas, the Periyar lands differ from the other deltas and this difference is reflected in the analytical results.

Malabar district.—In the nature of the soil surveyed, the Malabar district is different from the area previously surveyed. The previous surveys were confined to deltaic tracts, or as in the case of the Periyar, land brought under wet cultivation by an irrigation system. The soils were stiff and clayey and laden with the silt brought on year after year, by the river channels and distributaries traversing the tract. The crop grown was rice under swampy conditions. In the case of Malabar the area surveyed consists of low laterite plains and the soils, which belong to the red ferruginous series, consisting of a mixture of clay and sand; silt is practically absent or is present in very small quantities. The district cannot boast of irrigation facilities, a heavy rainfall taking the place of irrigation. The cultivation thus depends on the heavy south-west and north-east monsoon rains averaging about 100 inches annually and the area is not all under rice.

The collection of samples was, however, confined to the rice lands. The survey was done during the summer of 1922 and 1923 and 146 soil samples were collected in all. The analytical examination led to the following conclusions:—

The soils of Malabar generaly contain adequate supplies of nitrogen and may not require the use of nitrogenous manures. Practically the whole of the area is very deficient in lime and magnesia. The supply of total phosphoric acid is adequate, but the available amount is very low, and calls for immediate attention. As regards potash, the district shows a marked difference from the deltas. The total potash, which in the case of the deltas was eight to ten times as much as total phosphoric acid, is lower than the phosphoric acid; the available potash is just enough to meet plant requirements, but not in excess as in the deltas.

Summary of results of soil survey.—The results of all these surveys can now be advantageously summed up as recommendations for a manurial policy to be followed for the chief rice growing areas of our State.

The deltas of Tanjore, Guntur, Krishna and Godavari are deficient in organic matter, nitrogen, and phosphoric acid, but adequately supplied with potash. All these and especially Tanjore require immediate attention in the matter of supply of nitrogenous and phosphatic fertilisers. None of these deltaic areas need any potassic manures.

As regards Periyar tract, phosphoric acid is the limiting factor and this must be supplied. Further, although the present position as regards nitrogen is satisfactory, the practice of green manure must be continued to maintain the nitrogen level and to counteract against the possibility of alkalinity developing.

In Malabar, the crying need is lime, phosphoric acid to a slightly less extent, potash also. With a copious annual rainfall this tract has had all the bases leached out of the soil, like potash, lime and magnesia. Further, as the soil is rich in iron, care should be exercised in the supply of prosphatic fertilisers in a soluble form, because these phosphates will be converted into the insoluble iron phosphate, and become unavailable for crops. To meet this contingency, phosphatic fertilisers for the tract must be always accompanied by liberal doses of lime to fix the phosphoric acid and maintain it in an available form.

Special soil surveys.—These routine soil surveys of the rice areas of the Madras State were done at a time, when it was considered that an analysis of soils for their content of nitrogen, potash and phosphoric acid was all that was necessary to assess the fertility. With increasing knowledge in other countries and ours, the study of the soil profile and its characteristics and an examination for further soil properties marked a further stage in the technique of soil surveys. In particular, for areas to be brought under new irrigation projects, it was essential to go further than the mere estimation of plant foods. Soil studies thus done with specific objects like (1) suitability for and behaviour after irrigation, (2) possibility of introducing new crops and (3) the assessment of damage due to floods or tidal inundation, all come under this type. Some of these, which were done at the instance of the Irrigation Department have the following objects: (1) To study the various soil types prevailing in the project area, with a view to arrive at an approximate classification of soil types; (2) To obtain data on the physical properties, i.e., the structure and texture of the soils at different horizons in the profile and to study the effect of these properties on the permeability to water and the capacity for drainage; (3) To determine the nature and extent of soluble salts present in the various profile horizons and to estimate their depth distribution; (4) Based on the above studies, to determine whether the soils as studied are irrigable and if so, the probable effects of irrigation, i.e, whether irrigation would result in the rise or accumulation of soluble salts or result in water-logging; (5) To determine the type of irrigation, light medium or

heavy, that would be most suitable and give the best results, without bringing about the wholesale development of alkalinity; and (6) To suggest measures such as drainage and reclamation which may be likely to arise out of harmful changes on the advent of irrigation.

As would be seen, the above scheme is more elaborate than that followed in the deltaic soil surveys. The reason is not far to seek. It is generally considered, that if water is supplied, the problem of raising crops is automatically solved. Very often it is not so; irrigation projects start problems for the agriculturist, for it has been the experience in the world, that irrigation projects have brought in their wake, after the first few years of good crops, salt concentration, alkali formation and soil deterioration. Since irrigation projects require a heavy capital investment, in it necessary that a thorough investigation is carried out on all aspects, before the project is actually launched, as otherwise there is the risk of the capital invested all going to waste. Hence soil surveys for irrigation projects are always carried out in a very systematic and thorough fashion, with a special trained staff for all the operations, from collecting soil samples to carrying out the laboratory tests. The following surveys have been conducted during the past twenty years by the Chemistry section in connexion with the several irrigation projects contemplated in the State :—

(1) Lower Bhavani Project.
(2) Thungabhadra Project.
(3) Cauvery-Mettur Project.
(4) Gundlakama Project.
(5) Toludur Project.
(6) Gandikota Project.
(7) Bellary Fruit Development Scheme.
(8) Soil survey of cyclone-affected areas on the North-East Coast.

Lower Bhavani Project.—The project aims at putting up a dam across the river Bhavani at a place 9 miles west of Sathyamangalam in Coimbatore district and leading a channel from there to join the river Cauvery, near Chennimalai. The strip of land that lies between the proposed channel and the rivers Bhavani and Cauvery on the north and north-east is about 70 miles long and 4 or 5 miles broad, except near the Cauvery on the east where it is nearly 10 miles wide. The total area that would be commanded by the project is about 300,000 acres.

The soil survey of the tract was done during the summer of 1934. Soil samples were drawn from spots roughly 3 miles distant from one another and for the most part from dry lands devoted to raising only rainfed crops. These samples were taken for every 9 inches depth down to 27 inches. Some samples were also taken from adjoining garden land areas to see what changes those soils had undergone as a result of well irrigation.

Altogether 200 samples were collected from the project area and in addition to the estimation of plant food ingredients, they were examined with special reference to the organic matter present, their mechanical composition and other factors relating to the water relationship of the soil.

It was observed in the course of the survey that the soil was very shallow varying in thickness from 9 to 27 inches, with 17 inches as the average depth. The colour was uniformly red but in garden land areas the profiles showed deeper and more friable soils. The parent rock, gneiss, was usually reached at the third foot but just above it the ' B ' horizon showed a layer of friable weathered rock. The profile features could be described as below :—

0–17 inches	..	Red loam, often sandy or gravelly.
17–30 inches	..	Layer of broken quartz and crystalline felspar.
30–36 ,,	..	Red silty loam.
36–45 ,,	..	Weathered friable rock.
Below 45 inches	..	Hard unweathered parent rock.

The shallow nature of the soil connotes a limited amount of weathering due partly to the limited rainfall of 28 inches annually and the general contour of the land which favours a large run-off. The analytical data showed that most of the samples contained over 85 per cent of coarse fractions, i.e., gravel, coarse sand and fine sand. Of the remaining 15 per cent, the average clay content was only 4·5 per cent, a very low figure for such soils, which indicated a very low capacity for retaining moisture. The average moisture-holding capacity of the samples was only 26 per cent with many samples going down as low as 14 per cent and only eight samples had over 30 per cent of moisture-holding capacity. Under actual field conditions these laboratory figures would be much lower, nearly half. Specific gravity and pore space estimations also showed the extremely porous nature of the soil. It was calculated that an irrigation of 2·78-acre inches would be necessary to saturate the soil to a depth of 9 inches, while the corresponding figure for a 12-inch soaking was 3·71 inches.

Thus all the indications were pointing to the futility of copious irrigations on soils of this type. The soils were also very porous and considering the fact that the cultivation of wet-land crops like rice, sugarcane or bananas on such soils would mean the waste of large volumes of water, the recommendation was first made that only dry-land crop like cotton, ragi and sorghum should be grown under irrigation in this project. Experiments were conducted on selected ryots' fields under what may be called project conditions at Kugalur and Chinnasamudram and an account of the work done will be found in the Chapter on " Irrigation ".

As a result of these experiments it was concluded that the project would prove a success without any risk of alkalinity developing, because (1) of the excellent quality of the irrigation

water, (2) the open nature of the soil which would permit of free drainage and discourage the rise of salts from the deeper layers and (3) the diligence of the farmers of the tract who could be depended on to improve the fertility status of the soil if irrigation facilities were made available. To ensure success, however, it was recommended that anti-malarial measures should also be instituted with the advent of irrigation. Intensive propaganda should also be made to advocate the growing of green-manure crops with the addition of phosphatic manures in order to build up the fertility of the soils of the tract in nitrogen and phosphorus, two elements wherein the deficiency was most acute. Finally an agricultural research station must be established in the project area for testing various measures of land utilization to the maximum advantage and to study the agricultural and horticultural crops best suited to the tract under irrigated conditions.

The Tungabhadra Project.—The Ceded districts in Madras State, comprising the districts of Bellary, Anantapur, Kurnool and Cuddapah, have long been known as a region of very precarious and scanty rainfall subject to frequent famines, and as consequence, one of the most backward regions in the whole State. The Tungabhadra Project had been under contemplation for over 70 years as the only permanent means of improving the economic condition of the region as the soils, by virtue of their fertility and high water retention capacity, are able to produce good crops in years of timely rainfall. An attempt to harness the waters of the Tungabhadra river, which alone of the four rivers that run through this region has a perennial flow, was therefore under consideration for quite a long time. In order to settle the doubts expressed by some authorieies regarding the irregability of heavy black soils, a soil survey was ordered to be carried out in the tract to be brought under this irrigation scheme. Since the project was a major one, involving the outlay of several crores of rupees, the survey had to be on a very elaborate and detailed scale. A special staff was therefore instituted for this purpose, working under the control of the Agricultural Chemist in collaboration with the Irrigation Department.

The area to come under the project lies in the taluks of Hospet, Rayadrug, Bellary, Siruguppa and Adoni in the Bellary district, Pattikonda and Kurnool taluks in the Kurnool district, and Gooty taluk in the Anantapur district, with a total area of 1,072,500 acres, with 784,000 acres in Bellary, 160,300 in Kurnool and 128,300 acres in Anantapur district. The project is designed to have the storage dam at Mellapuram, a few miles south of Hospet with a storage capacity of 120,000 million cubic feet and a water-spread of over 138 square miles.

General topography.—The south-west of the area is hilly while the country to the east and north-east of Hagari is undulating, with a few low hills of red granite near Adoni. The general slope of the land is from the south-east to the north-west in general

direction of the Tungabhadra and its tributary the Hagari river. The soil of the region is mostly heavy black soil on which most of the rains that fall are lost as run off. The climate is what is known as 'Continental', i.e., with a low rainfall, high annual and diurnal variations in temperature and generally low humidity. This type of climate has had a profound influence on the process of weathering of rocks in the region, and has given rise to soils under arid conditions over very long periods. The total rainfall is only 21 to 22 inches, of which nearly 60 per cent is received in the south-west monsoon. In any given year, it is not so much the actual amount as the distribution of the rainfall that spells success or failure of crops. In some years the rainfall goes as low as 10 or 12 inches and often these rains are received as heavy downpours at a time when the fields are bare and easily eroded.

Geology.—The major portion of the region is composed of a basement o farchæan complex of granites and gneisses consisting mainly of types containing (1) quartz and felspar, (2) quartz, felspar and hornblende and (3) quartz, felspar and mica. The falspars themselves vary in composition being of both types, namely, soda lime and potash falspars. A peculiar feature of the region is that two or more of these rock types might occur together and give rise to different types of soil.

Hydrology.—The whole region is poorly supplied with wells and the water table lies at considerable depths below ground level. Conditions are somewhat better in the red soils, so that garden lands are sometimes found in the red soil areas. In black soil areas, the people have to depend for water on *Vankas*, where water is available from spring channels. Large storage wells are often excavated to catch the surface drainage during rainy months. These storage wells are known as *Vakkaranis* and provide a limited supply of water for domestic purposes. In a few places, fair sized tanks also exist, the *Daroji* and the *Kanekallu* in the south and the *Chinnatambulam* in the north are worth noting, as they irrigate a fair area and provide water for even wet cultivation.

Soils.—The soils of the area fall into two groups, the black and the red, almost entirely depending on rainfall. In certain limited areas, there are irrigated lands (both black and red) under river channels and under tanks. The cropping season varies with the nature of the soil; those that are cropped during the south-west monsoon being known as *Mungari* areas. These are mainly red soils which are less retentive of moisture. Black soils that are able to retain moisture for longer periods are cropped in *Hingari* or the later season, after the rains of the south-west monsoon are received. The *Mungari* crops are sorghum, setaria, bajra and pulses and also *Mungari* or early sown cotton while *Hingari* cotton and white sorghum are raised in the *Hingari* season.

Where conditions are favourable und water is available in sufficient quantities, crops like sugarcane and rice are grown in small areas. In Siruguppa, for example, there are nearly 3,000

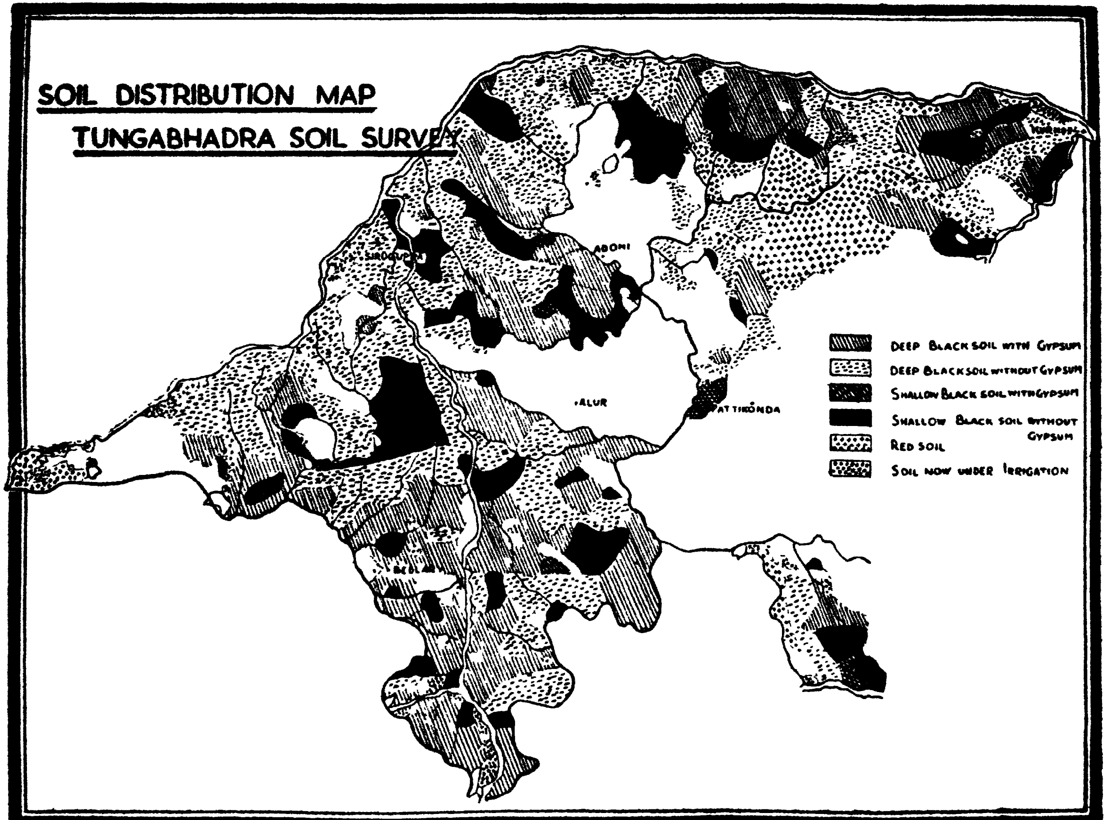


Plate 96.

P. 713

acres under channel irrigation from the Tungabhadra river. Rice, sugarcane, turmeric, bananas, garlic and sweet potatoes are grown and heavy yields are obtained. On the black soils, irrigated by spring channels from the Hagari river, rice is grown year after year and occasionally as in the village of Moka, sugarcane. These irrigation schemes have been in existence for nearly four centuries and should be a pointer towards the suitability of the soils of this region for irrigation.

The field work of the survey.—Survey work was commenced in the project area in January 1935; two field units took up the field work in February and completed it by the end of June. The project area covered about 1,600 square miles. At the rate of one profile pit for every four square miles, 400 pits were programmed. These were excavated down to the parent rock or water table whichever was less and a complete study of the profile was made and recorded on the spot. Samples of soil were drawn at depths of one foot or less so as to include all the special features of the horizons observed. Special profile pits were also dug in areas already under irrigation, to study the changes that had occurred as a result of irrigated conditions. The total number of profiles actually studied was 414 and the number of samples collected was 2,095.

Based on their colour, depth and the presence or absence of gypsum, the profiles taken from the dry areas, numbering 407, were classified as follows :—

Nature of soil.	Number of pits.	Percentage on the total.	
(1)	(2)	(3)	
1 Deep black soil with gypsum	128	31·4	79·8
2 Deep black soil without gypsum	108	26·5	
3 Shallow black soil with gypsum	15	3·7	
4 Shallow black soil without gypsum ..	74	18·2	
5 Deep red soils	5	1·2	13·2
6 Shallow red soils	49	12·0	
7 Mixed soils (unclassified)	28	7·0	

(*See* Map showing soil distribution in the Project Area.)

From the statement it will be seen that nearly 80 per cent of the profiles examined were black soils and of these 35 per cent contain gypsum, and 45 per cent no gypsum. A further analysis of the gypsum bearing pits revealed that gypsum most often occurs between the third and fourth foot which is thus the zone of salt concentration. This point, which was later confirmed by analysis is important, because it shows that the normal depth of occurrence of salts is not very high and is at a depth where plant roots will not be affected.

The following description of the profiles will be useful in bringing out differences between them :—

Deep black soil with gypsum.—The top soil is highly cracked, the cracks extending over four or five feet, as a consequence of which, a columnar structure is visible in places; in the deeper layers

no cracks are seen on account of the highly moist condition of the soil. The colour is black to light grey at the top, tending to become yellowish grey in the deeper layers. *Kankar* gravel is found distributed throughout. Gypsum occurs as crystal aggregates either at the zone of contact, between the upper and the lower layer or in the body in the lower layers. The yellow clay horizon is a characteristic layer of separation between the top and bottom portions of the profile and it is in this layer or near it, that the gypsum aggregates are found. In many of the profiles, irregular foliations at lower depths are visible and so the clay lumps present a lustrous ebony-like surface. The demarcation of the top black soil layer marked with cracks, from the subjacent moist, shiny, blacksoil layer is quite distinct. The underlying rocks when met with are highly weathered granite, giving rise to grey or light green material.

While the above is a general description of the deep black soil-gypsum profile, local variations are also met with. Calcium carbonate may occur either as pockets or as streaks of powdery consistency. It may also occur as dendritic incrustations in the lower horizons. Sometimes precipitated calcium carbonate in the form of powder, occurs in the deeper horizons. Ferruginous gravel may be found to be distributed either throughout the profile or confined to the yellow clay layer; the soil surface is found to be strewn with stones, especially near the water-courses, and smooth pebbles of varying sizes, and shapes are also seen.

Deep black soil without gypsum.—This profile is similar to the previous one, except for the absence of gypsum. Further, the yellow clay layer which is one of the marked features of the gypsum bearing profiles is often absent.

Shallow black soil with and without gypsum.—These two are similar to the deep profiles, but the cracks are not so deep, and the foliations and the yellow clay layer are not so distinct.

Red soils, deep and shallow.—The surface soil is mostly a sandy loam; generally red, the surface is lighter in colour than the lower zone. Usually angular stones, pebbles of granite and quartz are found distributed throughout with sometimes, calcium carbonate as *kankar* in the soil zone. The underlying rock is mostly weathered granite and the profile being loamy in texture, is permeable. In the shallow red soils, the depth of the soil zone rarely exceeds one foot.

Results of laboratory examination.—The soil samples drawn during the survey were examined in the laboratory at Coimbatore for various properties, physical, chemical and physic-chemical and the results are summarized below.

Mechanical composition.—All the four types of black soils possess more or less the same mechanical composition, characterised by over 60 per cent of the fine fractions, i.e., clay and silt. In the deep black soils with gypsum, the amount of fine fraction

increases with depth up to the fourth foot, the zone of salt concentration; it then falls till the seventh foot, with a further rise again at subsequent depths, if soil is present. With the rise in gypsum concentration, there is a corresponding fall in the amount of fine fractions indicating a direct correlation between salt concentration and the finer fractions. In the deep soils, the range of fine fractions is from 70 per cent in the surface to a maximum of 81 per cent in the seventh foot; in the shallow soils, the amount is less, from 62 per cent at the surface to 75 per cent in the third foot.

The red soils differ from the black soils in having a higher percentage of coarse fractions than fine fraction, the deep red soils are more loamy than the shallow ones, which are sandy loams.

The general mechanical composition of the different types, closely agrees with textural features of the profile recorded during the surveying in the field.

Single value constants.—To assess the general physical character of a soil, many workers have measured one property or a group of properties and specified it with a single number often referred to as " single value constants ". Hygroscopic co-efficient, maximum moisture holding capacity, pore space, the absolute specific gravity of a soil, are a few of these constants and there is a close correlation between these and the mechanical composition, especially fine fractions.

Laboratory examination of the project samples for these constants revealed that there is, in these soils, a considerable capacity for absorbing and retaining moisture. Clay soils as a group show a close relationship between the moisture retaining power and the fine fractions. With a rise or fall in the finer fractions, there is a corresponding increase or decrease in moisture holding capacity. But in heavy soils this property is not an independent one and is influenced by other factors, chiefly, by the bases present in an exchangeable form. Of these bases, sodium markedly affects the moisture relationship of the soil. Exchangeable sodium in the clay brings about a deflocculated condition in the soil, and increases its moisture-holding power over and above that due to the fine fractions.

The black soils of the project area, have a moisture-retaining power varying from 65 per cent to 85 per cent while the red soils (compare with the lower Bhavani project soil samples) show values from 25 to 40 per cent. Percolation and permeability studies showed again correlation with the clay content. Generally, the gypsum containing soils showed greater permeability, confirming the earlier observation that gypsum modifies the soil texture. In the case of red soils the rate of percolation was much higher than in the black soils, the depth attained by a percolating column of water being nine times that of the black soil over the same period. The slow permeability of the black soil is due not only to a high content of fine fraction but also to the exchangeable sodium.

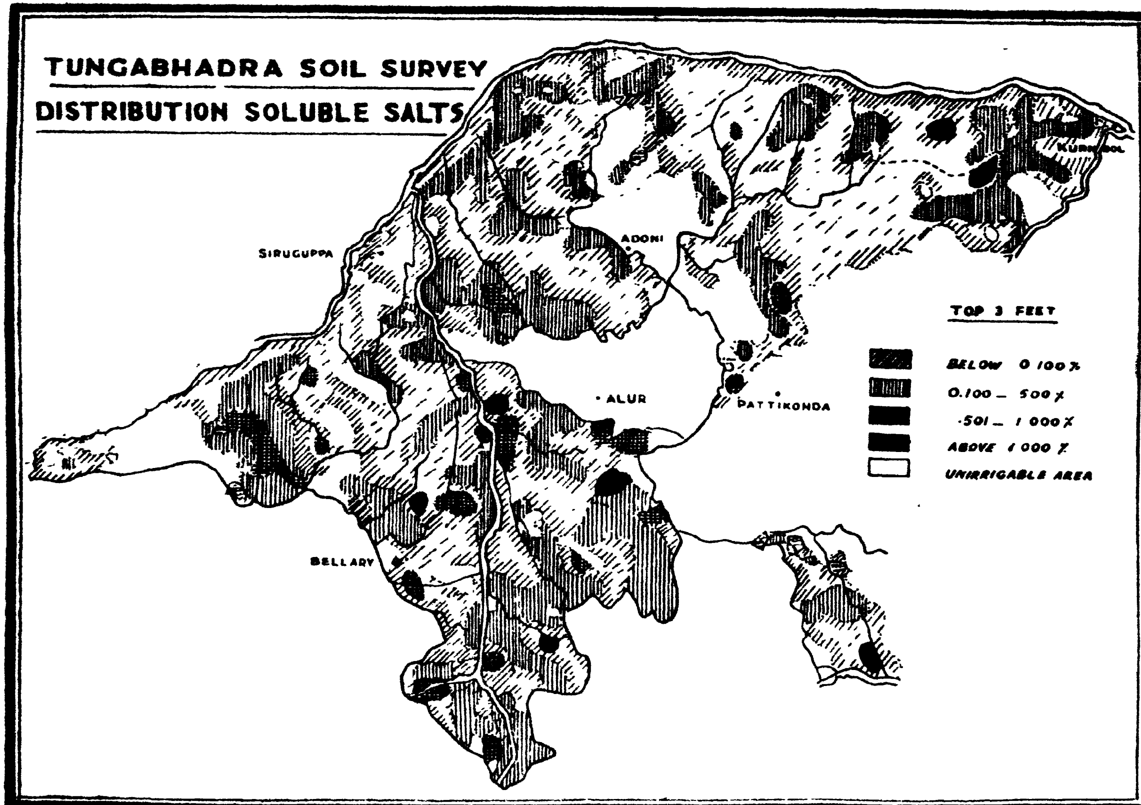

TUNGABHADRA SOIL SURVEY
DISTRIBUTION SOLUBLE SALTS
TOP 3 FEET
BELOW 0·100%
0·100 – ·500%
·501 – 1·000%
ABOVE 1·000%
UNIRRIGABLE AREA
SIRUGUPPA
ADONI
ALUR
PATTIKONDA
BELLARY

Plate 97.

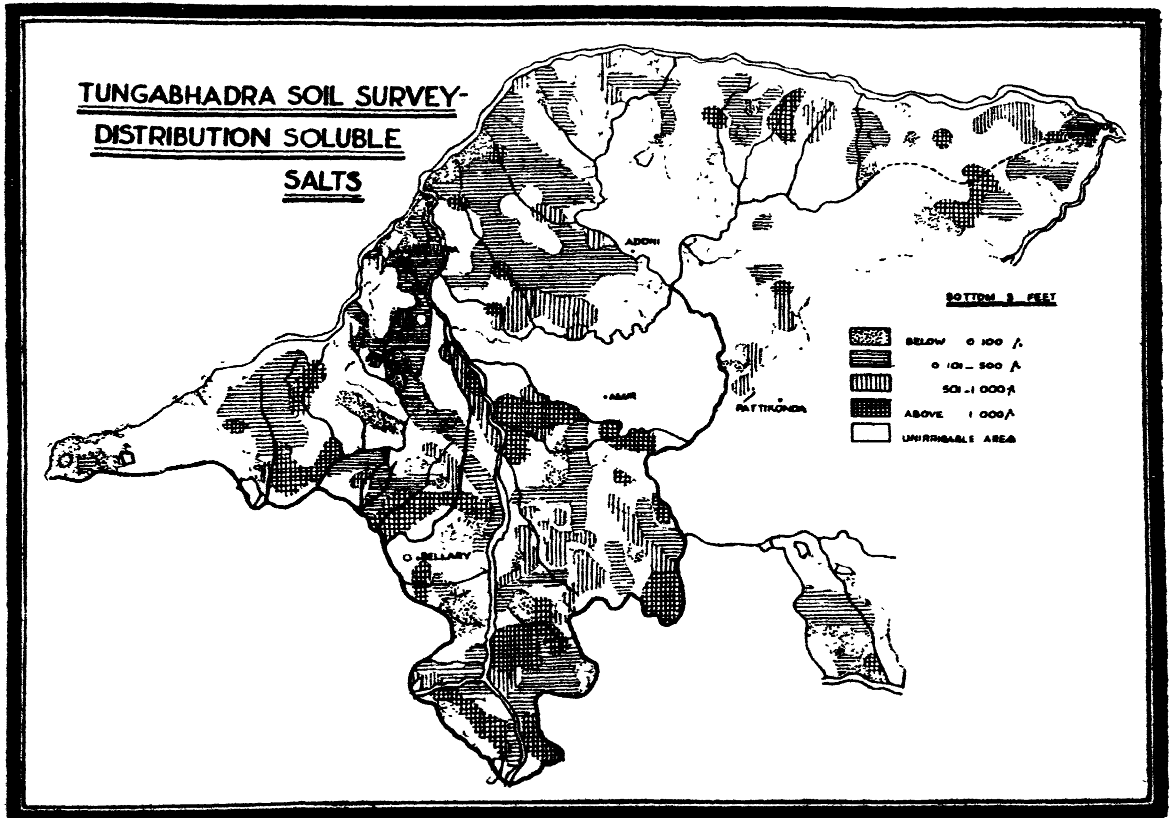


Plate 98.

P. 718.

Total soluble salts.—By far the most important laboratory examination done was the percentage of water-soluble salts. The following table gives the average salt content of the different soil types at various depths :—

Average salt content in percentages.

	First foot	Second foot	Third foot	Fourth foot.	Fifth foot.	Sixth foot	Seventh foot.	Eighth foot
1 Deep black soil with gypsum.	0·08	0·25	0·59	0·84	1·06	1·03	0·90	0·80
2 Deep black soil without gypsum.	0·06	0·10	0·17	0·21	0·27	0·34	0·33	0·23
3 Shallow black soil with gypsum.	0·11	0·32	0·91	0·80	..	..	..	..
4 Shallow black soil without gypsum.	0·06	0·10	0·13	0·19	..	..	..	..
5 Deep red soil ..	0·17	0·22	0·18	0·13	0·18	0·20	0·16	0·05
6 Shallow red soil ..	0·03	0·04	0·05	0·06	..	..	..	..

(*See* Maps of Project area showing distribution of total soluble salts in the top three feet and in the bottom three feet.)

It will be seen that there is an increase in the concentration of salts with depth in the black soil, the maximum being reached in the fourth and fifth foot, after which there is again a slight decrease. Generally the amount of soluble salts in the first foot is below 0·1 per cent very few samples having higher concentration. The range of concentration in the second foot is between 0·1 and 0·3 per cent and in the third foot between 0·1 and 0·5 per cent. Thus it is evident that in the region in which the roots of common agricultural crops are likely to penetrate, the salt concentration is at a minimum and not likely to be toxic to or inhibitory for plant growth. In the case of red soils, the salt concentration unlike, the black soil, is uniform throughout the profile, but the range 0·1 to 0·2 is well within the toxic limits.

The nature of soluble salts.—In assessing the effects of salts present in the soil on vegetation, it is not only the total concentration, but also their nature that are of importance. Crops may tolerate a high salt content, provided salts toxic to plant growth are absent; again, a soil with relatively low total soluble salt content, may prove incapable of bearing any vegetation owing to the presence of toxic salts. Hilgard and other American workers have worked out the toxic limits of various salts on heavy soils and found that 0·10 per cent of sodium carbonate, 0·25 per cent of sodium chloride and as much as 0·75 per cent of sodium sulphate are the limits of tolerance for most agricultural plants on heavy soils.

The analytical data on the project soils reveal that no carbonate was found in any of the salts examined, bicarbonates alone being present in appreciable amounts. The concentration of sodium

chloride and of sodium sulphate very rarely exceed the limits laid down by Hilgard. In cases where these limits were exceeded, the salts occurred only at the fifth foot and in zones which are not normally reached by the root systems of crops. In fact, high concentration of salts was usually associated with the zone of gypsum concentration. The salts at this horizon in the gypseous profile are mostly calcium sulphate (which is not harmful at all), sodium sulphate and a little sodium chloride and magnesium salts; there are traces of bicarbonates, and carbonates are completely absent. Even in the non-gypsum profiles, the gypsum is replaced by sodium chloride (not the carbonate) but the important point is, that in both the profiles the sodium salts are well within toxic limits, and are further counterbalanced by the presence of calcium in adequate amounts.

Exchangeable bases.—In assessing the changes that are brought about in soils by irrigation, three values, are important and these are, (1) the exchangeable bases, (2) the degree of alkalization and (3) the p.H. value. These are correlated properties and give an insight into the question whether a soil is alkaline or not to assist the effect of irrigation on it.

The exchangeable bases govern physical and physico-chemical properties of the soil like absorption and retention of moisture, the availability of plant nutrients, the formation of tilth and the facility for good cultivation and even the kind of crops that can be raised. The concept is based on the modern theory, that the clay fraction of the soil is the most reactive and that it contains colloids of different composition. These colloids exhibit surface phenomena to a marked degree, the most important of which is what is known as adsorption. Basic ions, residing on the surface on these soil colloids, are capable of being exchanged by other basic ions in an equivalent manner and the nature and extent of these ions on the surface decide the properties of the soil. The calcium ions, for example, develop a crumb structure and enable a soil to be cultivated over a wide moisture range and make it possible for a variety of crops to be grown. Sodium ions on the other hand, deflocculate the soil, render it impervious to water and the roots of plants, and bring about soil deterioration to a degree that renders it unfit for crop growth. Other ions like potassium, magnesium, etc., bring about changes intermediate between those of calcium and sodium.

The determination of exchangeable bases gives the total exchange capacity of the soil; from these the degree of alkalization is calculated as the ratio of the monovalent bases to the total bases, both being expressed in the same units. The base exchange capacity of a soil is usually expressed as the number of milliequivalents per 100 grams of the soil.

Deep black soils with gypsum showed an average capacity of 45 to 60 milliequivalents—a high figure which denotes a soil well supplied with exchangeable bases; those without gypsum had values ranging from 45 to 65; the shallow soils, with and without gypsum,

from 25 to 35, while the red soils had very low capacity of less than 25. In other words, the black soils have a high base status and the red soils a low one. Amongst the individual bases it was found that the sum of the exchangeable calcium and magnesium is fairly uniform throughout the profile; the exchangeable calcium however decreases and the exchangeable magnesium increases with depth. As regards sodium, although there was a general tendency to increase with the depth, the order of increase was characteristic of the type of soil examined. In the gypseous profile the surface contained five to six milliequivalents with a maximum of ten to twelve in the bottom most layers. In the non-gypseous layer, although the surface layer contained only five or six milliequivalents, there was an abrupt rise from the third foot downwards, the amount in the lower layers being thrice that at the surface. Shallow black soils, did not contain much sodium, the highest amount being less than five milliequivalents at all depths.

Degree of alkalization.—Working on the Punjab soils, Puri and others have shown that there was a correlation between alkalization and crop yields, there being a fall in the yield with a rise in the degree of alkalization. As long as the degree of alkalization was within 25 per cent, there was not much effect on the yield, but higher limits from 30 to 40 have been found to cause maximum dispersion in soils, destroying their crumb structure and depressed the yields. The degree of alkalization is thus a measure of sodium (a monovalent base) and the amount of exchangeable sodium in a soil has been known to be a limiting factor in crop production.

The figures calculated for the project samples regarding the degree of alkalization were very hopeful. Out of 91 samples examined only two had more than 30 per cent and 87 had less than 25 per cent. As a matter of fact, nearly three-fourths of the samples examined had less than even 20 per cent. These are well within the limits prescribed by Puri.

p.H. value.—The p.H. value is a measure of the nature of the soil reaction, whether it is acid, neutral or alkaline. Generally it is due to the hydrolysable salts present in the soil and is closely connected with the degree of alkalization and therefore also with crop yields. The figures obtained were however at variance from those of Puri in the Punjab. There, he had found that p.H. value increased with degree of alkalization and in the rice soils of the Punjab a p.H. value exceeding 8·5 was also found to decrease the yield. In irrigated soils under the Tungabhadra, however, even with a p.H. value of 9·5, the degree of alkalization was less than 25 and the yields were not affected. The Punjab criterion does not apply to the project samples, probably because of the high lime status of the Tungabhadra soils; this high line content while contributing its share to the raising of the p.H. value of the soil, kept the degree of alkalization at a low level.

Other estimations.—The project samples were also examined for other elements like nitrogen, potash and phosphoric acid and

the results showed the presence of adequate amounts of available phosphate and a deficiency in the amount of nitrogen.

Study of soil samples from the irrigated areas.—While thus all laboratory estimations on the project soil samples pointed to the irrigability of the black soil and indicated that no harmful results will accrue, consequent on irrigation, a study of the profile samples drawn from the irrigated areas of the tract also confirmed the above findings. Thirty-seven profile pits were examined under irrigated conditions. The irrigated soils of the tract fall under three heads: black clays, loams and sandy loams. In the upper reaches of the Tungabhadra near Hospet and Kampli, the soils are generally loamy; near Siruguppa and Kurnool the soils are deep black as also the soils under the Pedda Hagari river. The tank irrigated soils are of varied character and exhibit features in common with the dry area in which they occur.

Analytical data on the irrigated soil samples showed the influence of the quality of irrigation water applied to the soil. Under irrigation by Tungabhadra water, dry soils are likely to benefit by having their carbonates leached out to zones below root penetration. As a matter of fact the excellent quality of Tungabhadra river water is one of the deciding factors for pushing the project through. The average total soluble salts of the Tungabhadra river, as determined during six months of the year was only 15 to 16 parts per 100,000 while for Pedda Hagari and Chinna Hagari, the figures were 80 and 130, respectively. The water of the tanks of this area had also a higher salt content than the Tungabhadra. Further the Tungabhadra river water was free from carbonates and had very little sodium, while the other sources had appreciable amounts of sodium and carbonates. This accounts for the fact that while areas under irrigation at present under the Tungabhadra are maintaining good yields for the past several centuries, lands under the Hagari have developed already symptoms of alkalinity as for example at Moka village.

Conclusions—Summarized.—The results of the Tungabhadra soil survey and the laboratory examination of the soil samples collected can now be summed up: (i) The soils of the project area fall into three distinct groups—the black, the red and the mixed; the irrigated soils which contain all these form a separate group by themselves. The occurrence of a zone of salt concentration as indicated by the presence of gypsum, has been employed for further subdivision of the black soil group. (ii) Eighty per cent of the soils examined were black, of which 58 per cent were deep, and 22 per cent shallow. The remaining 20 per cent were made up of red and mixed soils. (iii) All the black soils are clayey in texture, with single value constants all directly correlated with the clay content. (iv) The moisture retaining power of the black soil ranged from 65 to 85 per cent. (v) The permeability of the black soils is low, but the presence of gypsum improves percolation and permeability. The red soils are very permeable. (vi) The salt distribution in the top three feet is fairly low in all soils. The

maximum average salt concentration noticed in the gypseous soil was 1·2 per cent, while the non-gypseous soils, it was within 0·5 per cent, often noticed after the third foot of the profile. (vii) The nature of the salts indicate the absence of harmful salts of the carbonate type. The other salts present are gypsum, sodium sulphate, sodium chloride and small amount of sodium bicarbonate. All these occur in concentrations not injurious to crops. (viii) The black soils have a high base status, with the exchange capacity ranging from 45 to 65 milliequivalents. The soils have also a high lime status, so that the degree of alkalization is low, i.e., less than 20 per cent in most cases. There is a gradual rise of exchangeable sodium in the deeper layers, the red and mixed soils have a relatively lower base exchange capacity. (ix) The p.H. of the soils ranges from 8·5 to 9·5 and this does not seem to affect crop yield or unfavourably influence the availability of the phosphate. (x) The soils contain sufficient available phosphoric acid but are deficient in nitrogen. (xi) The soluble salts in irrigation waters play an important part in bringing about changes in the soil characteristics. So far, Tungabhadra irrigation has not brought about any harmful changes in the black soils studied, although other irrigation sources have produced unfavourable changes due to the formation of sodium clay.

The issues at stake, consequent on irrigation under the Tungabhadra project, are enormous, with, on the one side, the fate of a country condemned by nature to be one of scanty rainfall and with a predominant soil of a nature hitherto considered unfavourable for irrigation and on the other, the equally enormous financial implications of the scheme. While the magnitude of the issues, therefore, suggests caution, the volume of scientific data obtained by the Government Agricultural Chemist as a result of this survey led him to recommend to the Government, that the black soil was irrigable with Tungabhadra water without any harmful effects on soil properties. He, however, made the following suggestions :—

Provision of proper drainage as an adjunct to the distribution.—While the natural drainage is good at almost all places, it is essential that a system of drainage is provided to facilitate the easy removal of all excess surface water and minimise the risk of water-logging. These drainage systems should be so arranged that there will be no possibility for drainage water to find its way into supply channels. The system of distributaries should have its corollary in a system of drainage channels, sufficient to carry away waters that drain from the surface quickly and efficiently. The importance of such drainage cannot be overestimated, especially in an area with a poor sub-soil drainage, and one in which the drainage water will probably contain salts, leached out from the soil.

A system of irrigation to obviate the indiscriminate use of water.—In the Nira valley canal in the Bombay-Deccan, one of the causes that brought about alkalinity was the indiscriminate use of water in the early years of the project. This was later remedied, when a carefully regulated system of irrigation was

followed. The conclusion that the black soils are irrigable should always be accepted with the rider, that they should be irrigated with care.

In addition to the above recommendations, the proposal that the laboratory examination on the soil done during the survey should be continued in the field was put forward. It was proposed that such experiments should be conducted *in situ* in some locality, typical of the project area. This proposal was given effect to by the Government and the result was the opening in 1937, of the Agricultural Research Station, Siruguppa. A detailed account of the work done at this Station will be found in another section.

As a result of the soil survey and the favourable report of the Government Agricultural Chemist, the Government were convinced of the black soil being irrigable and approved of the starting of the project. The construction of the dam has now been taken up near Hospet and the work is in progress.

The Cauvery-Mettur Project.—The Cauvery-Mettur project, as the name implies, has resulted from the impounding of the waters of the river Cauvery at Mettur. The main objects of the project were (1) the provision of an assured supply of water to the old deltaic areas of Tanjore and (2) the extension of irrigation to the uplands of the district, comprising the taluks of Tanjore, Pattukottai, Mannargudi and Papanasam. This upland area enjoys copious rainfall but the soils are very porous and of low fertility. The preliminary survey of this area was done in 1934, and indicated the necessity for extended and intensive study of the soil before a scheme of development could be suggested. A detailed survey was, therefore, taken up in the summer of 1936.

The project area and crops.—In addition to protecting the existing irrigation system in the Cauvery delta, the project was also intended to provide for the irrigation of 301,000 acres of new land in the aforementioned taluks of the Tanjore district. The major portion of the area is homogeneous in respect of the prevailing soil types; the one exception is the country lying between the Grand Anicut and Tanjore and a portion to the north of the Grand Canal which shows a marked diversity from the other soils. Otherwise the soil in the area is a sandy loam non-retentive of moisture. The water table is at 5 or 6 feet from the surface. Being situated mostly in the uplands of the district, the project area is more elevated than the delta, but it is an open plain sloping towards the east. No outcrops of rock are to be noted anywhere in the district. The general slope of the country is from north-west to the south-east and the fall is so imperceptible that the whole tract looks almost flat.

The drainage courses are further away from the irrigable area and most of the drainages are defective, the general contours not being favourable for efficient drainage. The high water table is another source of trouble, the area getting water-logged during the

rainy season. The district has a fairly high average rainfall, amounting to 45 inches per annum.

The geology of the area is very simple; no visible sign of the parent rock was met with during the survey. Over 90 per cent of the area is composed of a mixture of laterite and red soils and the rest of either black or red soils, with a Kankar or quartz substratum.

Only coarse, heavy yielding varieties of rice were commonly grown in areas irrigated by the tanks. On dry lands, rice was also raised as a rainfed crop. With the advent of the project, coarser varieties are being replaced by fine strains and transplantation is taking the place of the old broadcasting methods. The dry crops grown are, varagu, ragi, groundnut, sesamum and bajra. On the black soils occurring in the north, cotton and coriander are also grown as dry crops.

The field work.--The field work in connection with the soil survey was commenced in May, 1936. The study of profiles and the collection of samples were completed by the first week of June, 1936. The project covers an extent of three lakhs of acres or roughly 500 square miles. Based on the results of the preliminary survey of 1934, 42 profile pits were taken for study, which in addition to 14 taken in 1934, brought the total number of profiles examined to 56. The profiles were excavated down to bed rock or the water table but none exceeded a depth of 6 to 7 feet. The wet lands under tank irrigation were also included in the survey. The total number of samples collected was 223.

Profile classification.—In almost all cases, the soils were deep, the parent rock not being touched, but the water table which occurred in some cases at a depth of three feet and less, limited the depths to which the profiles could be studied. Depending on the age of wet irrigation, the soils could be divided into three major groups:—(1) The old wet lands; (2) the new wet lands; and (3) the deltaic wet lands. The profiles also showed differences in these three types. The old wet lands are those which have been under tank irrigation for a long time; the top three to five inches is sandy, followed by a layer of dark grey loam which shows a tendency to dry to a hard lump. The lower layer is clayey or loamy, with varying quantities of ferruginous gravel scattered throughout the profile; the water table is at a depth of two to two and a half feet and no distinct horizons are visible in the profiles of this group.

The new wet lands comprise the areas which have been included in the command of the project; some have been under wet cultivation for a short period and some others are awaiting conversion into wet lands. The soils of these new wet lands, with particular reference to which the soil survey was conducted, may further be classified into four types:—Red soil, Red loam, Light loam, and Black soil. The first three especially light loam, is the predominant soil type of the tract. It is characterized by the presence of a highly leached out sandy surface soil extending to a depth of six to eight inches. The subjacent layer is a hard crust

of loam very difficult to work and extends to a depth of six to eight inches; below this again, soil is met with of a loose porus texture if the water table does not intervene. The soils of this type can be classified as deep, with the water table generally five to six feet below the surface.

The black soils under the new wet lands contain black clay admixed at the top foot with kankar nodules and ferruginous gravel. In the lower layers these are absent. But after the fifth foot there are again plenty of kankar nodules. The water table in this profile is generally six to seven feet from the surface.

The delta wet land soils are entirely different from those of the old or new wet lands. They are all alluvial in origin, being silty soils admixed with kankar. Deep cracks extending to a depth of a foot or a foot and half are often noted. The lower stratum below the third foot is a sandy loam containing shells, kankar nodules and yellow clay. The water table is at four to five feet from the surface.

Laboratory examination.—The main laboratory examination consisted of mechanical analysis, maximum moisture holding capacity and related physical measurements, the water soluble salts—their nature and extent, the exchangeable bases and the exchange capacity, the hydrogen ion concentration, the lime requirement and the chemical analysis of the surface soils for nitrogen, potash and phosphoric acid. The results of the laboratory examination are summarised serially below :—(1) Mechanical analysis. In the old wet lands group, there is noticed a fairly uniform distribution of fine fractions throughout the profile, the general trend of results confirming that the soils are of secondary formation, developed from the accumulation of eroded soil from the surrounding regions.

The new wet land soils invariably contain a highly leached zone at the surface six to eight inches deep and the amount of fine fractions in this is only 11 to 12 per cent. The subjacent layer consists of highly compacted soil with 30 to 35 per cent fine fractions. The red soil contains the highest, the red loam the lowest and the light loam an intermediate amount of fine fractions, but there is a general tendency for the fine fractions to increase with depth.

The black soils of the new wet land group are heavy clays, containing over 70 per cent of fine fractions which here also increased with depth.

The delta soils are characterized by the presence of high amounts of fine fractions at the surface, which decrease with depth; the texture of the lower layer merges almost on sandy loam. Nowhere in the uplands is seen such an ideal mechanical condition of the delta soil. This distinctness in composition would establish the individualistic formation of the delta soil, as opposed to the other groups studied.

Maximum water holding capacity.—The soils of the new wet land group which were particularly examined, did not show a direct relationship between the fraction content and the moisture held by the soil, probably because of the low amount of fine fractions. In general, the soils have poor moisture content and the retentivity of moisture is also very low. The figures obtained indicate that it is imperative to improve the moisture holding capacity of the soil, if irrigation is to yield any beneficial results.

Water soluble salts.—The salt content of the red and loamy sub-groups of the new wet lands is very low and there is no danger of alkalinity arising from the salt content of these soils. In the soils of the old wet lands, however, a fairly high salt content was noticed in some of the profiles examined; these were scattered occurrences and not general and can probably be traced to irrigation with water from tanks. In Pattukottai taluk, the old wet land in Kurichi and Papanad, showed a marked concentration of salt, and again in Mannargudi taluk the profiles examined at Vadavur, Parayanad and Adanur showed even higher salt concentrations. These profiles were in hollows and the concentration was evidently due to the accumulation of washed salts. No such concentration was observed in any of the new wet lands, but the occurrence in the old wet lands point to the importance of providing drainage to prevent stagnation of water and the consequent accumulation of salts through a period of years.

The black soils show a gradual rise in salt content with depth from about 0·01 to 0·26 per cent. But the concentration even in the lower layer is so low as not to cause any harmful effects on the crops raised. The nature of component salts was determined in detail wherever the total soluble salt content exceeded 0·1 per cent; it was noticed that the bases other than sodium were absent, the bicarbonate and chloride of sodium being predominant salts. As the soils of the project area possess low moisture retaining power it is quite likely that the critical limit of concentration in such soils would be very low. Unless, therefore, proper precautions were taken, even this low amount may prove toxic to the crops raised.

Exchangeable bases.—The soils of the new wet land group have very low exchange capacity and are generally unsaturated. Even within this group are noticed some variations; the red soils possess the highest while the light loam and red loam have the lowest exchange capacity, the range being fom 1 to 3·5 milliequivalents. The exchangeable calcium is very low being of the order of one milli-equivalent while the other bases are present in very insignificant amounts. The old wet land soils have medium amounts of exchangeable bases averaging 21 milliequivalents with a fair amount of exchangeable calcium.

The exchangeable sodium increases from the surface downwards. This partly explains the relative impermeability of the deeper layers.

Under actual field conditions the adverse effect of soda clay is manifested in the poor yields of rice raised on these soils. The presence of large amounts of exchangeable sodium in this type of soil which appears to be otherwise well supplied with bases may have to be viewed with a little apprehension as this might obstruct the subsoil drainage and gradually set up conditions for unfavourable crop growth. The black soil in the new wet land group is highly saturated with bases. The replaceable calcium is present in large amounts and decreases with depth. With a decrease in calcium there is noticed a corresponding increase in the magnesium and sodium content. This would connote an unfavourable character of the deeper layer and with the application of water the soil may develop a tendency towards the formation of soda clay. The delta soil has a fair exchange capacity but not approaching that of the black soil. The soils are fairly well supplied with exchangeable calcium and the replaceable sodium is not present in high amount. Excepting the black soil, none of other soils in the Project area possess an exchange capacity comparable to that of the delta soil. This indicates the ideal conditions of the delta soil and incidentally the line of attack that will have to be pursued to improve the soils of the tract.

It may be stated in brief that the great majority of the soils in the uplands have a low base status which is mainly due to their low content of fine fractions and to the peculiar nature of the clay complex.

Hydrogenion concentration.—The p.H. values of the soil varied in general with the degree of saturation. The soils of the new wet land group have their pH less than seven in conformity with their low base status. The red soils have a pH of nearly seven. The old wet lands, the black and the delta soil have a higher pH with a tendency towards rise with depth.

Chemical analysis and lime requirement.—The new wet land soils are poorly supplied with all the essential plant foods. The old wet lands, though poor, are slightly better while the delta soils are also poor as seen in the delta survey, being supplied only with potash. The lime requirement examination indicated that a quantity of about six to ten tons per acre of calcium carbonate applied at the rate of about three tons per annum for two or three years would be required for the new wet land soils. The results of the soil survey are definite and may be summarised as follows :—

The main soil type met with in the commond is the light loam, which occupies about 95 per cent of the area, the rest being black soil. These light loams are sandy or sandy loams, with low moisture holding capacity, low base status, low fertility and low lime status —all conditions unfavourable for plant growth.

Based on these results two definite recommendations can be made, one on manuring and the other on drainage.

Manuring.—It is essential that the fertility of the soil should be improved. The soil as already pointed out is a sandy loam not very retentive of moisture and with a low fertility status. The main plant food elements, nitrogen and phosphoric acid, are in deficit and these must be added in liberal quantities. The light, porous nature of the soil makes it imperative that organic matter be added to make the soil more retentive of moisture. Another urgent necessity is the addition of lime to the soil. To recommend immediate heavy application of manure as well as of lime is a counsel of perfection. It cannot be expected that such application can be attempted in the whole area at once, on a scale to really benefit the soil. A very much more feasible plan will be to attempt to build the general fertility step by step. To do this, it is recommended that vigorous propaganda must be carried out to encourage the growing of green manure crops. It is also recommended that experiments on the actual lime requirement of the soil be undertaken at the Agricultural Research Station, Pattukottai to give more definite information than the laboratory tests indicated.

Drainage —The country is one of low gradient, the fall being about three feet in the mile. Such gradients would tend to cause stagnation of water in hollows and danger from salt concentration as was seen in a few cases in the old wet lands. In any irrigation project it is desirable that a system of drainage is included side by side with the supply channels, and in the case of the Cauvery-Mettur Project area, this is all the more important on account of the low gradient and the porous nature of the soil. Trouble has occurred in other project areas for example, the Toludur in South Arcot and Kattalai high level channel area in Tiruchirapalli where alkalinity has arisen owing to impeded drainage and it is recommended, therefore, that steps be taken to provide suitable drainage in the areas with outfalls into the natural drainage of the country.

Based merely on these results of the soil survey no definite recommendation can be made regarding any alternative system of cropping for the area. The survey had shown that the fertility of the soil must be first built up and meanwhile suitable experiments have been laid out at the Agricultural Research Station, Pattukottai to study suitable crops and their reactions to the conditions of the project area.

The Gundlakamma Project.—The river Gundlakamma takes its rise in the Kurnool district partly as a drainage from the Cumbum tank. The catchment of the river appears to be mostly in the region of the rocks of the Kurnool-Cuddapah formation, an area of moderate rainfall. The site of the proposed dam is at Tangirala about four miles upstream from Gundlakamma Railway Station on the Bezwada-Guntakal line. The dam is for storage purposes and it is proposed to lead the water to the anicut at Janumalamedaka for distribution from a canal at Kotikalapudi, about two

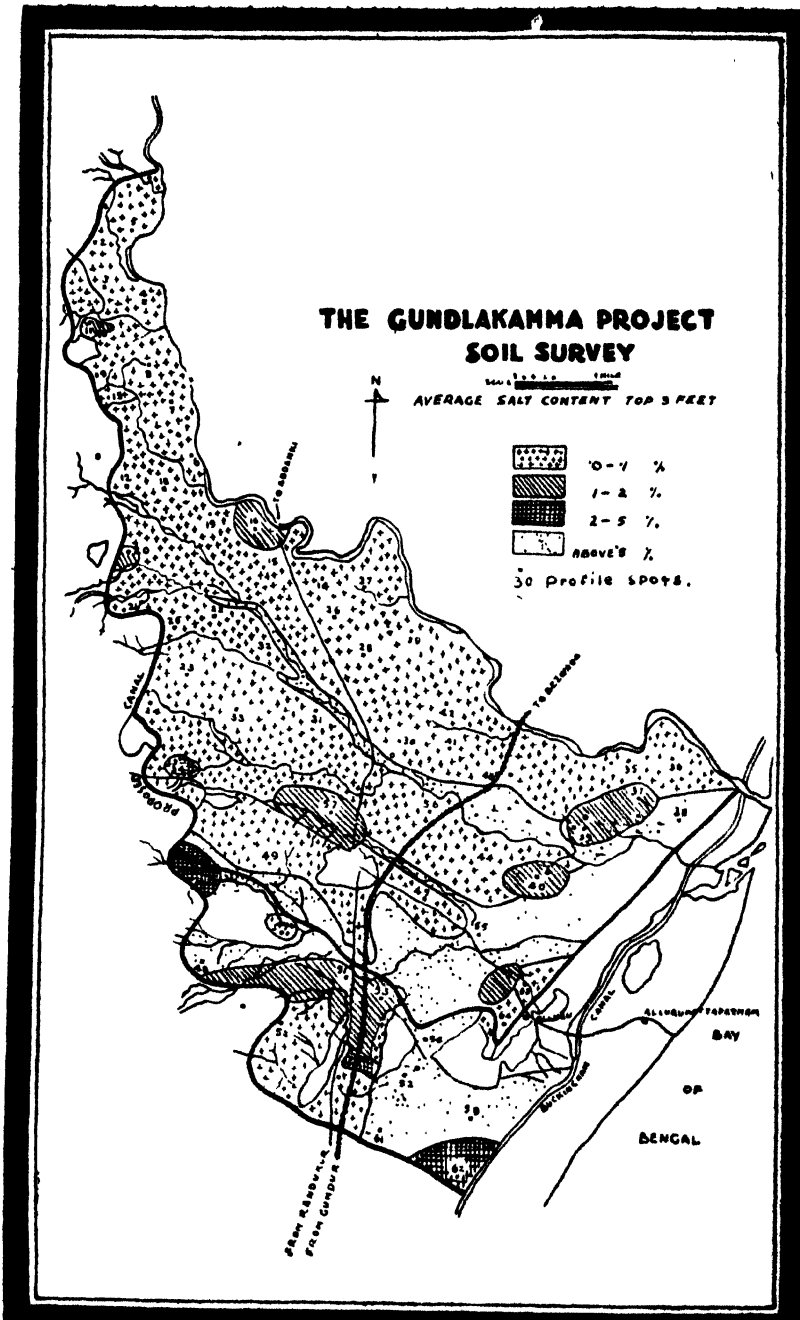


Plate 99. P. 730.

miles south-east of Addanki, in the Ongole taluk. The river Gundlakamma falls into the sea a few miles from Ongole town.

Topography.—The topography of the command, which is mostly in Ongole taluk of the Guntur district, is generally flat with contours running roughly north-west to south-east. There are a few isolated hillocks of granite and quartzite in the north and granite schists in the east. The southern part between Ongole town and the sea is sandy and flat, especially near the coast, where there are many large tanks supporting wet cultivation; the rest of the area is saline down to Buckingham canal.

Field work.—The survey was started in the month of March 1937, the main object of the soil survey being: (1) The investigation of the soils of the command, (2) the suitability of the soils for wet cultivation, and (3) the quality of Gundlakamma river water for one full season.

While the method of soil surveying was the same as that in the Tungabhadra Project, it would be noticed that the objects were slightly different. The Tungabhadra Project was essentially a protective scheme, and further, doubts regarding the irrigability of the dry black soil had to be set at rest. There was no apprehension about the quality of Tungabhadra water. The Gundlakamma Project was for productive purposes, to bring the land under wet cultivation and the river water was not so good as that of the Tungabhadra.

Sixty-four profile pits were dug in the command area at convenient intervals, and 398 samples were collected at an average of one sample per foot from every six feet profile depth.

Climate and crops.—The annual rainfall of the area is about 28 to 30 inches, of which the south-west monsoon contributes 10 to 11 inches while the north-east about 15 to 16 inches, there being very little rainfall associated with the inter monsoon period. The area is subject to heavy rains during the passage of cyclonic storms in the Bay of Bengal in the months of September to November. The staple crops of the area are dry crops, mainly varagu and sorghum, other important crops being tobacco (area under which is largely increasing), chillies, groundnut, bajra, setaria, cotton, horsegram, gogu, castor, sesamum and coriander. Rice is grown under tanks in a few places like Mainampadu, Erlalur, Pellure and Alluru.

The condition of the cattle is generally good and the pastures of the tract are of good quality. In fact the tract is important for its livestock grazing and the Ongole breed of animals has a great reputation in the country.

Geology.—The major part of the command is alluvial in origin, overlying a gneissic complex, the gneisses at places being schistose and at other places micaceous. Quartzites occur near Pernamitta to the east of the command and near Ongole give rise to red soils.

Laterite has been observed in the river beds. Large areas of blown sand are to be found near the sea coast covering the black alluvial soil. The water-table throughout the area is fairly high and particularly near the channels it rises to about four to five feet from ground level.

Soil profiles—Classification.—The soils may be classified into four main classes: (1) Black soils, (2) mixed soils, (3) red soils and (4) saline soils. The black soils vary in depth from three to eight feet and in colour from grey to brown. Though the surface soil resembles that of Bellary on account of the cracks developing during summer, there is no zone of salt concentration and gypsum is usually absent; in some localities where it occurs, it is found not in one horizon as in the Tungabhadra profile but scattered throughout the profile, as small crystals. The black soils are clay loams or heavy clays, the mixed soils are mostly loamy and the red soils sandy loams.

The saline soils though classified so separately do not represent any particular type but have been rendered saline by water from drainage channels. Surface drainage is generally good, being directed towards the Gundlakamma and the sea, but owing to shallow contour and high water-table stagnation of water occurs during the rainy season, especially in the salt swamps near the Buckingham canal. Much of the land under tanks is alkaline with low drainage capacity, having been damaged by sodium from the tank water.

There is one main drainage Mudigundi Eru running parallel to the Gundlakamma slightly to its south and flowing into the salt swamp near Alluru. This drainage has given rise to saline soils, in a belt on both sides of the drainage. The soils in this belt are highly saline and the salt swamp has no other vegetation except a halophyte specimen called *Uppaku*. It is reported that adjacent lands get spoiled by saline sand blown from this region during windy weather. Such lands can be seen near Throvagunta on the Ongole–Guntur road. There is one other drainage the Nallavagu to the south of Ongole which has also developed a saline area along its banks and which also empties into a salt swamp; but this swamp is less developed than the one covered by Mudigundi Eru.

Laboratory examination.—The laboratory determinations on the samples collected during the survey were similar to those done for the Tungabhadra project area and the results of the analytical examination are summarised below.

The greater part of the command to the north of Ongole has a salt content of up to 0·1 per cent in the first three feet and also in the second three feet; in other words, the salt content is uniform upto a depth of six feet and does not show any increase with depth as in the Tungabhadra project samples, but the concentration of

harmful salts is not present in any degree liable to cause damage to crop growth, nor is it likely to cause damage to the soil by rising to the surface after irrigation. In this demarcated area roughly representing the wet scheme area, the profile does not have any marked features because of its alluvial nature. This area can be demarcated by a line running north of Ongole town parallel to the sea and it is this area alone which can be declared as suitable for wet irrigation.

The area south of this line and that along the Mudigundi Eru with its saline strip, is unfit for irrigation, especially a 'dry scheme' because the soils have a high salt content over one per cent. The salts are all sodium salts; further, due to a high water table the soils are all ill-drained.

The mechanical analysis of the sample showed that the soils of the upper part of the area are generally clay loams with 60 to 65 per cent of fine fractions while the soils of the lower part are heavy clays with a high water holding capacity.

The soils of the command have a fairly high amount of exchangeable bases, the total base exchange capacity being 30 to 40 milliequivalents, in most samples. Of this, more than half is calcium and except in the saline areas, the degree of alkalization is well below 25 per cent.

The pH value of the soils was high, between 8·5 and 9·0 but as seen already in the Tungabhadra project samples, this need not be a deterrent to crop growth. The chemical analysis showed the surface soils to contain adequate amounts of the essential plant foods, nitrogen, potash and phosphoric acid.

All these examinations being favourable, a periodic examination of the water from the river Gundlakamma for one full year was also done, since there is a belief among the ryots of the area that the water of the Gundlakamma is not fit for irrigation. The analysis showed that the total salt content of the river water varied from 16 parts per 100,000 during the floods to about 70 parts in the dry months of the year. Since the period during which the water will be stored will be that of the maximum discharge in the river. that is, the flood period, it is reasonable to expect that the water supplied will have a composition mostly resembling that of the flood water and at any rate the average salt content may be put down at 30 to 40 parts. Though the water was not of ideal quality for irrigation like the Tungabhadra water, there is no reason to apprehend harmful effects, by irrigation of land for wet crops.

Conclusions.—Based on the soil survey, the observations made during the field work and the laboratory study of the samples of the soil and water collected, the following conclusions could be arrived at :—

Of the two schemes proposed for this area, the wet and the dry scheme, the wet scheme is more feasible. The soils with their

characteristic physical properties and their high fertility status will respond favourably to wet cultivation. The water of the Gundlakamma though not ideal—since it contains sodium salts—for irrigation purposes, is not likely to produce ill effects in wet lands. But not all the area of the command is fit for wet cultivation. The most suitable is the upper part of the command beginning at Kotikalapudi down a line running parallel to the sea coast, a few miles north and north-west of Ongole town, and above the saline area induced by Mudigandi Eru and Nallavagu.

One precaution is necessary for this wet cultivation; manuring with bulky organic manures like cattle manure and oil cakes and the growing of green manure crops should be adopted to minimise any possible ill-effects of the continuous application of Gundlakamma water for irrigation. Provision should also be made for draining the surplus water into the natural drainage of the country.

The Toludur Project.—The Toludur Project, whose reservoir has been subsequently named the Willingdon Reservoir, is in Vridhachalam taluk of South Arcot district. The reservoir has been built at Kilcheruvai village, intercepting the course of a wild stream known as Periya Odai, which formerly was functioning as a drainage channel. The stream which takes its origin somewhere near Salem, is one of the main feeders of the reservoir and being a torrential one, has, it is alleged, the capacity of filling up the reservoir with one fresh, following a rainfall on the hills. There is a second source of supply to the reservoir from the Vellar river, through the main channel from the regulator built at Toludur village; but this supply is allowed only after two anicuts lower down the river, Pelandurai and Settithope, have had their needs fully served.

The reservoir commands an ayacut of 26,851 acres under wet crops, most of which lies in the Vridhachalam taluk. The soil survey of this command serves as a good example to illustrate how a systematic and scientific survey could set at rest, points of dispute, about the suitability of an irrigation source and the land commanded by it, for raising wet crops. What happened, was, that after the construction of the reservoir, the Government wished to reclassify the lands and provide field channels for irrigation. There was some objection from the ryots to this especially to the reclassification of the lands, which would result in a charge of wet assessment for them. There was therefore a tendency on their part to exaggerate their previous income and minimise the output after the reservoir came into existence.

One of their main contentions was that the Periya Odai stream, which was the main source of supply to the reservoir, was salt laden and caused injury to crops. They also claimed that more water should be given to their crops, than was then allowed under the

reservoir; otherwise, there would be no justification for reclassifying their lands and charging wet assessment. Government therefore ordered that the question of the saline nature of the irrigation water and its effect on the lands of the area should be examined. A soil survey by the Government Agricultural Chemist was the result.

The survey was made during the month of March 1935. Eight villages were selected from the area and from these 32 soil samples were collected. The profiles were examined only to a depth of three feet and from each profile pit, three samples were drawn. In addition to the soil samples 11 water samples were also drawn for analysis. These were from (1) the actual irrigation system at different places, (2) from the Periya Odai and the Vellar river, (3) from a tank Tivalur eri into which one of the main distributaries emptied, and (4) from dramage channels near Tolar village, near which was reported to be the worst affected lands. Monthly samples of water were also drawn for a period of one year, from the reservoir, the Periya Odai and the regulator in the Vellar river.

The samples of soils and waters were examined in the laboratory for the usual estimations. The soils were found to be clay loam with an average percentage of 55 of fine fractions, of which the clay alone was about 40. The maximum moisture holding capacity ranged from 47 to 64 per cent; the porespace and the hygroscopic coefficient similarly showed the clayey nature of the soil. The examination for total soluble salts—their nature and extent—showed that in this area, the salt content in the top three feet is between 0·05 to 0·1 per cent—a low figure.

But the calcium salts were low and sodium salts were predominant, chiefly sodium bicarbonate. In many of the samples calcium salts were completely absent, sodium salts making up the entire total. The figures indicated that while the content of total soluble salts is low, the presence of sodium salts might lead to concentration in the course of years, if drainage is not good.

One particular sample of soil analysed threw some light on this aspect. This sample had been drawn in a dry area, which had not so far received irrigation. The total soluble salt content of this sample was 0·8 per cent at the surface layer and more than one per cent in the third foot. In a sample drawn from the wet area, in the same village Tolar the surface samples had more salts than the bottom. At the time of sampling it had been noted that there was no water at a depth of three feet. Evidently, with irrigation, the water level has risen, bringing with it, the salt from the lower layers to the surface. This example would serve to show that if drainage is not provided, there are chances for concentration of salt at the surface, in course of time.

The examination for exchangeable bases also confirmed these findings. The total exchangeable capacity is between 20 and 30 milliequivalents and sodium is the predominant base. The degree of alkalisation in the first and second foot samples was also high,

being in some cases over 60 and up to 92. Particularly in Tolar village, already referred to, the exchangeable sodium was very high. The pH value of the soils was over 8·0 showing them to be alkaline; and as the lime status is very low in these soils, the degree of alkalization has become very high.

Chemical analysis of the samples showed the surface samples to be fairly well supplied with plant food elements although there was deficiency in nitrogen and organic matter; one point elucidated in the course of the chemical analysis was, that in these soils, total soda was rather in excess.

While the examination of the soil samples thus led evidence to show, that with bad management, the soils are likely to develop alkalinity, the examination of the water samples showed that there was no justification for the ryots' belief that the water was salt laden. The water samples from the distributaries showed a total salt content of 26 parts per 100,000 which calcium and sodium salts in equal proportion. It would have been ideal to have larger proportions of calcium salts in these waters. Still, this water connot be expected to have any adverse effect by itself, unless it be that the nature of the land irrigated is very alkaline or laden with sodium and is without proper drainage facilities. On the other hand, with proper drainage provided, this water might wash out the harmful salts from the soil itself.

The reservoir water shows the same analysis as the samples from the distributaries. The samples from the Vellar river and from Perya Odai have higher salt content, about 40 to 60 parts respectively. Even the sample drawn from the drainage channel at Tolar had only a total salt content of 82 parts, which is not a high figure for a drainage sample. But as the sample contained over 70 per cent of sodium salts and chiefly as the carbonate, it shows that the drainage is likely to contain salts leached out from the surrounding area and unless led out into proper channels, is likely to increase the salt concentration of the surface layers of the soil.

The soil survey thus showed, that the chief cause of trouble in this area was defective drainage. If this is improved, the lands could be safely cropped with wet crops and reclassified as wet lands. The drainage facilities in the area are inadequate and unless measures are taken to remedy this defect by constructing open drains, any amelioration to correct the soil will be of no avail. The alkaline areas in the command have all been observed only in localised patches formed as a result of seepage water stagnating. Kothattai and Tolar villages are the two that appear to have been most adversely affected. Application of organic matter, preferably green leaf or manure must be done to the soils at a dosage of 5,000 lb. per acre. In addition, the soils will benefit by application of lime or gypsum at about eight to ten cwts. and sulphur at about 100 to 200 lb. per acre.

It is generally noticed that the lands at the tail ends of the system are more affected than the others. This may indicate a general insufficiency of water supply to these areas. An adequate supply of water will not only keep the salts in the lower regions, but even wash out harmful salts from the surface. It may therefore be stated, that with a liberal supply of water allowed and with a more thorough drainage system the yielding capacity of these lands may be kept up.

The Gandikota Project.—A perusal of the accounts of the special soil surveys in connection with the several irrigation projects aforementioned would have convinced the reader of the need for a scientific and systematic examination before a new area is to be brought under irrigation. It would also have been noticed that in practically all the above cases, the results of the soil survey were encouraging and the Agricultural Chemist could recommend the inauguration of the projects, although with precautions like manuring and drainage being provided. One case which came under the purview of the Chemist where he had to give adverse opinion on the proposed irrigation scheme was the Gandikota project. It is at Gandikota, there is the famous gorge, through which the river Pennar flows towards the east and the proposal was to erect a dam near this gorge and utilise the flood waters of the Pennar for the raising of dry crops in Cuddapah district. This tract also, like the Tungabhadra Project area, is an arid one, with scanty rainfall and it was considered that a similar attempt as on the Tungabhadra might be made on the Pennar although on a small scale. The scheme was thus a protective scheme and the tract proposed to be benefited was in the Jammalamadugu taluk of the Cuddapah district. There was even a proposal to open an experimental farm to study the effect of light irrigation on the soils, with Pennar water.

As a preliminary, soil samples were collected from eight typical profile pits in the area, comprising Jammalamadugu and adjoining places. The flood waters of the Pennar river were also analysed periodically.

Laboratory examination of the soil samples showed that the soils which were black were highly clayey except along the banks of the river, containing over 60 to 70 per cent of fine fractions. While thus they resemble the Tungabhadra Project samples in their clay content, there was a marked difference in the total soluble salt content. Analyses showed the Gandikota soils had a high salt content even at the surface and this increased still more with depth. It was further seen that sodium carbonate was the predominant salt in these soils which had a very low lime status and a high pH value—nine.

The Pennar water too was not of good quality, as it contained over 130 parts of salts per 100,000 and of these, the carbonates and chlorides of sodium were predominent. In view of these features, a verdict was given against the project. It was in fact pointed out that the nature of the water and the soil would in

combination create a very serious problem and indicated the need for extreme caution in the introduction of irrigation in this area.

Soil survey for fruit development in the Ceded districts.—With a growing recognition of the value of fruits in the nations' dietary, the need has been felt in recent years to find out fresh areas that are suitable for new orchards. In the Ceded districts there are at present several areas where citrus gardens flourish and fetch good returns to the owners, and a soil survey was ordered by the Government in 1946 to assess the suitability of the following areas in the Ceded districts for fruit development :—

	District.	Taluk.	Area.
1	Bellary	Kudligi	Kottur-Ujjaini.
2	Kurnool	Sirvel	Rudravaram.
3	Do.	Cumbum	Giddalur-Diguvametta.
4	Cuddapah	Sidhout	Vontimitta valley.
5	Do.	Rajampet	Kodur firka.

The scheme was sanctioned as part of the Grow More Food Campaign, half the cost being met by the Central Government. The field work involving the collection of soil and water sample from the five areas were carried out during August to November. Eighty profile pits were dug and 426 samples of soil and 51 samples of water were collected and complete descriptions of the soil profiles and other relevant details were recorded. Based upon these and the laboratory examination of the samples, the suitability of these areas for fruit culture was assessed as given below :—

Kottur-Ujjaini area.—The red soils on the area which lies on either side of the Kottur-Ujjaini road are derived mainly from granites with pegmatite veins. Over the greater portion of this area, the soils are shallow not exceeding two to three feet in depth, although in the valley lines they are deeper (five to seven feet) and reddish brown in colour. They are also full of stones and gravel which range from five to ten per cent of the sample. The water table is very low at a depth of 60 feet and irrigation wells are few. This water is in addition very brackish and contains over 100 parts of total salts per 100,000 nearly half of which is in the form of sodium salts. This area is not suitable for fruit cultivation as the soils are too shallow, water table too low and the water brackish.

Rudravaram-Sirvel area.—Rudravaram is situated at the foot of the Nallamalai hills and is about ten miles from the taluk headquarters, Allagadda. The soils in this area are mostly derived from the Cuddapah formation. They are brown loams overlying a yellowish sub-soil having a higher proportion of clay. Often ferruginous gravel is found in abundance in the deeper layers. In and around Sirvel the soil zone extends to about three or four feet but in Rudravaram area sufficiently deep soils are met with. Here the texture is sandy loam to loamy. Whereas the water at Sirvel is rather high, being less than five feet, it is sufficiently low in Rudravaram, at a depth of 20 to 30 feet. A number of new orchards

have come into existence near Sirvel in recent years on account of good returns from oranges but in view of the high water table in this area and insufficient drainage, the life of these gardens may not be long. From the survey it was found that both in Sirvel and Rudravaram the quality of irrigation water was quite good as the total salts rarely exceeded 50 parts per 100,000 and had also a good proportion of calcium salts. The Rudravaram soils are sandy loams which are more open in texture than the Sirvel soils. The tract gets an annual rainfall of 22 inches, mostly in the north-east monsoon.

In spite of the fact that the orchard area is extending round about Sirvel, the survey indicated that Rudravaram was a better area for orchards, on account of the greater depth of soil, better drainage, depth of water table and the quality of the water-supply. The main handicap is its unaccesibility due to lack of good roads.

Giddalur-Diguvametta area.—Here too, the soils are mainly derived from Cuddapah formations with abundant calcium reserves. Near Diguvametta the soils are shallow but increase in depth towards Giddalur. The drainage is generally good except in certain areas like Kanchipalli. Except near Diguvametta, loamy soils of sufficient depth for fruit cultivation, five to six feet, are met with on either side of the Kurnool-Guntur road. The main drawback is lack of water as the water table is at a depth of 50 to 60 feet and the cost of sinking wells is high. On account of this no large scale development of the area is possible.

Vontimitta area.—This is an area where fruit culture has already made good progress, Vontimitta oranges being well known for their quality and colour. The average rainfall is 32 inches mostly from the north-east monsoon. The soils are derived from sand stones, but due to considerable erosion stretches of good soil are not extensive. The colour of these soils varies from red on the hill slopes to grey on the remaining areas. Most of the soils contain high proportions of stones and gravel. The water table is high and good quality water is available even in summer. Laboratory tests showed that the soils are sandy loams with good drainage and well supplied with potash and lime. The quality of water was very good as the total soluble salts were only 11 to 40 parts per 100,000 and contained very little of sodium salts. The chief drawback in this area is that due to erosion large stretches of good soil are not available in continuous blocks.

Kodur area.—Kodur is well known as an important fruit producing centre and is famous for its mangoes, limes and oranges. There are nearly 7,000 acres of oranges and 10,000 acres of mango gardens in Rajampet taluk, most of which is in the Kodur area. The rainfall is 38 inches, well distributed between the two monsoons. The outstanding feature in this area is the deep red soil, of more than eight feet depth in places with excellent drainage. The soils are mainly derived from quartzite and are in general red or reddish brown in colour and uniformly loamy in texture down to

eight feet. Being derived from quartzite the soils are poor in plant food elements and contain very low amounts of nitrogen, potash and lime. The water table is at the ideal depth of 20 to 25 feet, the quality excellent with only 30 to 40 parts of total salts in which calcium salts predominate. The drainage also is good and as such all conditions are favourable for a considerable extension of fruit culture in this area except in a small area in Settigunta where the soils are very poor and the water table also very low.

Summarising the results of this survey it may be said that the only locality where fruit cultivation can be extended is the Kodur firka, where all conditions are favourable. In Vontimitta, isolated patches can be converted into orchards and in Rudravaram also if road communications are improved. The Kottur and Giddalur areas are definitely unsuitable.

Soil survey of the Cyclone-affected areas in the North-East Madras Coast.—A disastrous cyclone struck the North-East Coast of Madras in November 1945. Meteorological records show that as many as 214 cyclones developed in the Bay of Bengal during the period 1683 to 1886 and on an average one cyclone occurs almost every year though the intensity is seldom so severe as it was in 1945. In this year the storm wave was quite an extensive one covering a stretch of 150 miles along the coast from Masulipatam to Puri. Soils over large stretches were rendered unfit for cultivation and the water in tanks and wells became brackish by contamination with sea water. As one of the measures of cyclone relief the Government of Madras sanctioned in November 1945 a scheme of soil studies in the area inundated by sea water, to assess the nature and extent of damage to the soils and to see what steps could be taken to render such lands fit for growing normal crops once again. After traversing the cyclone affected area, 423 samples of soils and 64 samples of water were collected for analysis. It was observed in the course of the survey that the coastal lands were inundated directly by the tidal waves, while the higher lands on the delta suffered an indirect inundation. The storm waves rolled over the Godavari and raised the level of water in the river, which was already in spate on account of heavy rains in Hyderabad, by nearly six feet and as a result the river overflowed its banks and inundated the whole deltaic area. The river water mixed with sea water damaged large stretches of fertile lands and the standing crops. The coastal areas, where the inundation was by sea water, suffered even more as the high salt content of 3·2 per cent not only ruined the standing crops of sugarcane, rice and bananas but also left behind toxic amounts of salts in the soil. Rice crops that got submerged in sea water were all destroyed by the high salt content besides rotting due to prolonged submergence. The tail end fields suffered most in the uplands even though the crop did not die completely. Its metabolism was disturbed and the surviving plants failed to set grains. The straw got blackened and became so saltish that animals refused to eat it. From numerous fields, where the normal yield was from 10 to 15 bags of rice, the yields

were as low as one or two bags of immature grains unfit for seed or human consumption. Bananas and sugarcane got badly lodged and damaged by submergence and even coconuts which can tolerate salinity, suffered because the salt concentration was too high and gave only very poor yields.

The analysis of soil samples indicated that sea water had soaked into the first as well as the second foot of the soil. The total salts ranged from 0·03 to 5·92 per cent of which 70 to 90 per cent consisted of common salt, i.e., sodium chloride. Analysis of irrigation waters were also carried out to determine their salt content and see how far they could be utilised for leaching out the excess salts by flooding and draining off. It was found that the Godavari water contained very low amounts of salts and in addition there were mostly calcium salts as well. The water was therefore highly suitable for the reclamation of inundated lands. Further analysis showed that the composition of the water flowing in different channels and in different seasons of the year was practically the same. It was also noted that the maximum amounts of salt were leached out of the soil by allowing the irrigation water to stand in the field for a day or two and a longer period was not more helpful. Repeated flooding with moderate quantities of water at short intervals and draining away was thus more effective in removing most of the salts than letting in water continuously or in large quantities at long intervals. By such methods it was found that nearly three-fourths of the total salts in the upland areas, and about 20 per cent in the tail end area were washed out during the *dalwa* or second crop season in 1946. If better drainage facilities had been available in the tail end area it could also have been reclaimed more effectively.

Incidentally the salt tolerance of different varieties of rice was studied both in pot experiments and field conditions. The variety SR 26 was found to be the most saline tolerant among all the varieties tested. Such of the fields as contained a greater concentration of salts than the critical limit of 0·25 per cent required more water to dilute the salts to a level tolerated by the variety of paddy that is to be grown therein and this dilution should also be maintained throughout the growing period of the crop as otherwise it would get scorched. Pulses and legumes failed to grow even in the upland regions where the salt accumulation was very much less.

Another line of investigation was to see if the damage caused could be remedied or at least minimised by suitable fertiliser treatments. It was noted that in places where the seedlings had turned pale, top dressing with ammonium sulphate or groundnut cake produced a remarkable improvement because the soils were initially deficient in nitrogen (as revealed by the soil survey of the delta) and the leaching out method of reducing salinity aggravated further the depletion of nitrogen and organic matter. The application of nitrogenous manures and lime is therefore very necessary and

until the soils were reclaimed sufficiently to permit the growth of leguminous green manure crops, it would be better to apply green leaf manure to hasten the amelioration. The incorporation of such bulky organic manures as well as ammonium sulphate and groundnut cake would not only benefit the crops but also reduce the chances of the soil becoming alkaline. The traditional local method for leaching out the salts whenever sea inundation takes place in this tract is to plough in large quantities of damaged rice straw, along with whatever cattle manure that is available. The land is then puddled and drained off and the process repeated three or four times at intervals of seven to ten days. Rice seedlings are then transplanted and water let in and allowed to flow either continuously or intermittently. In this practice it has to be recognised that rice straw though organic matter is mostly carbonaceous and hence sufficient nitrogen in the form of ammonium sulphate or groundnut cake should also be added to keep up the nitrogen status of the land during draining and further lime also must be applied to prevent the formation of unfavourable clay composition.

SOIL MOISTURE AND DRY-FARMING PRACTICES.

Among the numerous factors that influence crop growth, the most important is the amount of moisture in the soil. In areas where the rainfall is low and no facilities exist for irrigation, soil moisture becomes a limiting factor in crop production and the main object of the cultivator resolves itself to one of conserving the limited moisture that is available in the soil to the best advantage of the growing crops. The black soils of Bellary, and particularly the area where the Hagari Agricultural Research Station is situated, is a typical area. The rainfall is one of the poorest in the State being only 21 inches on the average and is also not well distributed as more than half of it is received in a month or forty-five days' time between September-October. The main crops, cotton and sorghum, have to depend on the rainfall that is received before sowing them, as the rains received during crop growth is practically negligible.

In 1927, certain preliminary studies were commenced at the Hagari station on the effect of different dry-farming operations. A similar set of treatments was tested at Coimbatore in the Central Farm fields for correlating crop yields with laboratory examination of soil samples immediately after each treatment. The general conclusions from nearly eight years of these studies at Hagari were that (1) bunding was advantageous in increasing yields of sorghum and cotton, especially in years of low rainfall, (2) it was not necessary to do deep ploughing oftener than once in five years, (3) that ploughing to depths of less than ten inches had no effect on the yields and (4) that cattle manure well incorporated into the soil helped to increase crop yields. Similar studies at Coimbatore showed that bunded plots retained more moisture.

The importance of the problem and the results achieved in the preliminary experiments indicated the need for a more detailed and systematic investigation and in 1934, the Madras Dry Farming Scheme was started at Hagari under the auspices of the Indian Council of Agricultural Research, as part of a general All-India Scheme at four centres, namely, at Sholapur (Bombay), Hagari (Madras), Raichur (Hyderabad) and at Rohtak (Punjab). A summary of the finding on the various aspects of dry-farming research during the period of this scheme from 1934 to 1943 is given below.

Since much of the rainfall that is received in this tract is lost as run off on account of the heavy impervious nature of the soil and carries off large quantities of the rich surface soil, experiments were conducted to determine the amount of water loss from surface run off. Plots with a specific gradient of one in 80 were enclosed on three sides with galvanized iron sheets and the run off from the fourth side was collected in cement cisterns for measurement and analysis. During 1937–38 and 1938–39 the effect of cropping the land with different crops in controlling run off was also studied.

The data showed that 41 to 48 per cent of rainfall was lost as run off. The silt that was washed off amounted to 9·9, 8·6 and 7·4 tons per acre respectively for a rainfall of 15·7, 9·2 and 8·4 inches for the three years under study. Cropping reduced the run off by half in the case of rain water and the loss of soil by two-thirds. Analysis of the washed off soil showed that it was richer than the original soil, having twice as much nitrogen and four times as much potash.

Estimation of soil moisture at different depths in the field was done for various treatments such as bunding, deep ploughing once in four years and working the basin lister and compared with controls, namely, no bunding and no ploughing. The results of four years' trials indicated that the formation of small bunds seven inches high helped in absorbing the rain water, as also scooping the surface of the field by means of the implement known as Basin lister. The data revealed that the moisture content increases with depth but when any layer approached about 25 per cent of the moisture there was a greater rate of percolation downwards due to the continuity of moisture films. After the September and October rains all the layers up to the fourth foot had the maximum moisture content.

In a fallow land the loss of moisture by evaporation was very little, indicating that the moisture is carried over and becomes available during the next season for crops. At Hagari, the soil below the top three inches forms into a hard impervious layer nearly eight to nine inches in thickness consequent on the shrinkage which the soil suffers on drying. Losses of soil moisture by evaporation were most pronounced in the top 12 inches of soil. So the layer between three and 12 inches become very hard if the

desiccation is rapid, after the rainy period. If this hardness sets in during the early stages of crop growth the plants suffer very badly and hence conservation of moisture has a vital bearing on delaying the formation of this hard layer as a result of desiccation and shrinking. This phenomenon of shrinkage was investigated in detail over different ranges of moisture in black soils. It was found that 165 cubic feet of soil when dried completely shrink to about 100 cubic feet in the laboratory. Under field conditions this shrinkage might be less due to presence of coarse particles. If desiccation of the top three inches were prevented by timely hoeing, the shrinkage of the soil below was lessened and the formation of the hard layer delayed. Hoeing and the moisture condition of the soil at hoeing had thus a very marked effect on the yield of crops.

The second foot of soil had a much greater power of retaining moisture than the first foot even though both the layers were closely similar in physical composition. Some interesting results were also observed on the hygroscopic co-efficient of the soil. This important soil constant is a measure of the capacity of the soil to get into moisture equilibrium with the surrounding atmosphere. It is a constant which is closely related to the texture of the soil. Experimental data revealed that the amount of moisture absorbed by a soil at a given relative humidity varied with the time and could be expressed mathematically as an exponential equation. When a soil was alternately wetted and heated, it was found to suffer a loss in absorptive power. Similarly when a soil was ignited it lost its absorptive power by about 50 to 80 per cent in heavy soils and 40 to 60 per cent in the case of light soils.

Studies on the variations in soil nitrogen in fallow, cropped and manured plots showed that the fallowed plots contained the lowest amount of nitrogen and that the top six inches of manured plots contained the highest amounts. A crop of sorghum removed 14·4 lb. of nitrogen per acre and 5·33 lb. of phosphoric acid.

Daily observations of soil temperatures at different depths showed that the seasonal variations in temperature were felt down to two feet, though the maximum range of variations was naturally found to occur at the soil surface In cropped plots, the surface temperature was about five degrees lower than in the open. With increasing height of crop the temperatures inside the crop and in the open tended to become equal.

Observations made in the field on different crops under different cultural treatments were in line with the laboratory findings. Thus it was found that the formation of the hard layer due to desiccation and soil shrinkage was the cause of crop failures in the tract, as it prevented the roots from penetrating into the deeper moist layers of soil below. The roots were often found to be strangulated by the drying soil in plants which had dried up in this manner indicating the need for evolving quick-growing short duration

varieties that could elaborate their root systems before the hard layer is developed.

One such variety among sorghums is M 47-3 which has done well in all seasons and particularly in droughty areas. This strain is now popular and is gradually displacing the previous standard strain T-1 of the tract. To shorten the duration still further crosses were made between certain American varieties like Milo and Wonder and local sorghums and their progenies are under study.

Root studies were also made on different crops at different stages and gave very interesting results. It was seen that at every stage the plant assures itself of an adequate subterranean equipment before enlarging the aerial parts. The roots that were passing through the cracks developed a special mechanical protective tissue and were purplish in colour instead of being light brown like normal roots. Short duration varieties had smaller root systems than longer duration types.

The amount of moisture in the soil had a direct correlation with root development. The tip of the primary adventitious roots in most cases dried up after a few days and when the soil moisture was adequate numerous long secondary roots are formed often extending to four feet in length behind these tips and radiates into the soil in a fan-like manner. This type of secondary root development was not evident in seasons of deficient rainfall. It was noticed that in bunded and fallow plots the root development was always better because of the higher moisture content in these plots. Another observation was that in Setaria high winds curtailed the growth of both shoot and root in the plants.

Bunding.—From the agronomic standpoint, it was noted that bunding helped to increase crop yields. This was more marked in years of deficient rainfall. When land was ploughed periodically and bunded it did not show any advantage over unploughed and unbunded land in the year it was ploughed but in subsequent years the effect was very marked in the shape of increased crop yields in plots ploughed and bunded particularly if the season was one of poor rainfall. For low gradients of one in 400, seven inch high bunds formed with the bullock drawn implement known as the "bund-former" were quite effective and also economic as the operation costs only four annas per acre on the average.

Fallowing.—Fallowing in alternate years gave nearly double the annual yields, and this effect too, was more pronounced in droughty years. If sorghum was grown after a preceding fallow season and cotton in the third year the good effect of fallow was seen even in the cotton crop but if cotton followed a fallow season and then sorghum came after the cotton crop the effect of the first year's fallow was not so very distinct on the sorghum crop in the third year.

Spacing.—A series of experiments on the optimum spacing for crops proved that 18 inches between rows was the best for sorghum while 36 inches (three feet) were the most economic for cotton. The effects of manuring whether with compost or farm yard manure directly or indirectly were visible only in years of good and sufficient rainfall in the case of sorghum and cotton but for setaria, due to its shorter duration, manuring was helpful even in years of poor rainfall. Farm yard manure applied at less than five cart-loads or 5,000 lb. per acre failed to show any effect on crop yields.

Mixed cropping.—Growing cotton as a pure crop was more profitable than as a mixture with *setaria*. The local practice of mixtures of setaria-groundnut or setaria-horsegram were profitable only when sown sufficiently early in the south-west monsoon. Sowing pulse crops in the Mungari (south-west monsoon) season and drilling sorghum in rows in between the rows of pulses was found to be both inconvenient and uneconomic. Pure sorghum gave higher money returns than its mixture with pulses.

The local practice of growing two or more crops in mixtures is because the ryots wish to have both a food crop and a money crop, e.g., setaria-cotton apart from its serving as an insurance against total failure. Such mixtures seldom fare well due to the severe competition for soil moisture between the root systems of the two crops as they feed in the same zone in the soil. On the other hand mixtures like setaria-horsegram or groundnut-setaria are always found to thrive better because the roots of horsegram feed in the top layers while setaria roots go deeper in the soil. Where mixtures like setaria and cotton have to be grown it is always preferable to grow them in the strip cropping system than as a mixture in the same rows. Strip cropping reduced root competition with no extra expenditure. It also helps in reducing soil erosion. Of all the crops tried for conserving the soil against erosion after heavy downpours, groundnut was the best followed by setaria and with cotton as the least effective as an anti-erosion crop. Mixtures of setaria with groundnut were found to have the highest anti-erosive value.

A similar type of investigation was carried out in 1936 to 1939 in the red soils of Anantapur district as a complement to the work on the black soils at Hagari as the climatological conditions and rainfall were similar though the soil was different. The soils at Anantapur are red, very shallow and coarse in texture. Three places were selected in Anantapur district, namely, Anantapur, Kadiri and Hindupur, and at each centre four trials were conducted on ryots' lands. The object of the trials was to improve the water holding capacity of these shallow red soils, by giving light ploughings and forming bunds as at Hagari. The treatments tried were (1) ploughing with a light mould board plough (like cooper 26), (2) bunding with the bund former, (3) ploughing with wooden (country) plough and (4) not bunding (ryots' practice).

The trend of the results was for an increased yield in the Cooper ploughed and bunded plots. Shorter duration crops like cereals were benefited to a greater degree than long duration crops like redgram or groundnut.

Incidentally it may be of interest to mention some early studies made at the Agricultural Research Station, Kasaragod, during 1923 to 1928 on the utility of frequent stirring of the top soil as a means of conserving soil moisture. It was found by experiment that plots that were frequently stirred on the surface retained more moisture than untreated plots. Manuring also was found to aid in a greater retention of soil moisture. The average yield of coconuts per tree, recorded over a period of eight years, was 59 per year from the manured and cultivated plot. The cultivated and unmanured plot gave an average yield of 52 nuts per year, while the control plot that was neither manured nor cultivated yielded only an average of nine nuts per tree. Another interesting soil moisture trial was at Nileshwar where the practice of burying coconut husks between rows of coconut palms showed that there was an increase of soil moisture and yield of nuts by this practice.

Soil Erosion and its Control.

In arid and semi-arid tracts that are in general subject to sudden downpours of rain the problem of soil erosion is a serious one as it leads to a steady impoverishment of the soil. The prevention of soil erosion is intimately connected with dry farming practices especially in the Ceded districts in Madras. Experiments at Hagari have shown that with every heavy shower of rain there is a loss of the fine surface soil to the extent of seven to nine tons per acre per year. This washed off soil was also found to be richer in plant nutrients so that the losses by erosion are serious enough to demand the most urgent attention. But even in the advanced countries of the West, it is only in very recent times that soil erosion has been recognized as a national danger. In India, barring the few experiments done at Hagari and other dry farming research stations, no real attempt has been made so far to either assess the magnitude of the losses involved by soil erosion or to devise any large-scale measures for preventing such losses by erosions. Besides the loss of much soil, erosion leads to the silting up of tanks reducing their storage, a rise in river beds making them shallow and subject to floods.

The soil is the uppermost disintegrated layer of the earth's crust. Its average depth is about 6 to 12 inches though sometimes it is known to extend to a depth of 8 feet or more even. Soil erosion is the transportation of soil from one place to another through the agency of water or wind in motion. Under natural conditions undisturbed by man, an equilibrium gets established between the climate of a place and the cover of vegetation that protects the soil layer. A certain amount of erosion does take place even under this natural cover but it is a slow and very limited

process which is balanced by the new soil that is formed by weathering agencies. Under intensive agriculture, this balance is upset and the removal of soil takes place at a faster rate than its renewal by soil forming processes.

Wind and water are the two agencies that cause soil erosion. Wind erosion in Madras at any rate is not so widespread as water erosion and exists in a serious form only in certain places, such as along the river banks of the Hagari and Pennar rivers where during summer when the river is dry high winds during the south-west monsoon months blow the sand to great distances covering up the black soil fields on either side of the rivers. Control measures have recently been taken up by the Forest department along the Hagari river bank by planting quick-growing trees along the banks to fix the existing sand dunes and prevent them from getting blown still further off.

Erosion due to water is much more widespread and more serious. Extensive erosion occurs in many parts of our State, particularly in the Ceded districts, coastal areas and in the Nilgiris. Two main types of erosion are sheet erosion and gully erosion. In the former, movement of run-off water and eroded soil occurs in sheets. When this moving sheet assumes sufficient velocity its cutting action on the soil is increased and this results in a trench or gully being formed at any weak point or depression in the surface. If the velocity of the run-off water is doubled its energy is increased four-fold and its erosive action on the soil is correspondingly increased and its capacity to carry soil particles is increased 64 times. The gullies tend to get deeper and wider with every succeeding rain and eventually cut up the agricultural land into fragments and making it unfit for cultivation. Of the two types, gully erosion is the more evident and spectacular but sheet erosion is really the more dangerous as it is insidious and is seldom noticed before it is too late to remedy its destructive effects.

Heavy soils, as are found in the Ceded districts, are highly susceptible to erosion as they are slow to absorb rain water on account of their high content of clay fractions. In the absence of sufficient organic matter in these soils, the clay tends to become " deflocculated " and gets very hard when dry and very sticky when wet. This stickiness impedes absorption of rain water still further and when more rain falls all the fine particles broken down from the crumb structure of the soil are washed off on the surface and carried away with the run-off water.

The amount of run-off depends on the intensity of the rainfall. A heavy storm in a few hours causes as much or even more damage as all the rains during the rest of the year. This is because a gentle rain does not pulverise and break down the " crumb " structure of the soil and the soil is able to absorb the water and accumulate it in the deeper layers—for the use of subsequent crops. In the black soils of the Ceded districts, the main " Hingari " crops are harvested by March or April after which the land remains bare of vegetation until the next September or October. The

distribution of the rainfall in this tract is such that out of a total precipitation of 20 inches for the year about 12 inches are received during the months of August-September and October when there is no protective vegetation. Further it is common during this period to have one or two thunderstorms amounting to nearly 2 to 3 inches overnight, and such storms cause a lot of damage by soil erosion.

Contour and erosion.—Another factor that influences the speed and extent of run-off is the slope of the land, the greater the slope the greater being the velocity of flow. The Nilgiris, for instance, are subject to severe erosion during the rainy season and large quantities of the rich surface soil are lost in the rushing torrents through hill streams and gullies. Further, the practice that prevails on the Nilgiris of cultivating potatoes on the steep slopes without any proper anti-erosive measures and of leaving the soil in a very loose condition after the harvest of potatoes in July-Auguse,leads to severe erosion on these hills.

Measurement of run-off losses.—Losses of soil and water by sheet erosion have been measured at the Dry Farming Station at Hagari which has been mentioned earlier under dry farming research. The following table gives some typical results.

Run-off data, 1937–39.

Black soil; Hagari Agricultural Research Station; Bellary district; gradient of plots 1 in 80; area of plot 1·25 cents each. One plot was the control, i.e., kept as clean fallow and the other plot was scooped into small pockets or " basins ".

	1937–38. Average of two control plots both kept fallow.	1938–39 Control plot.	Scooped plots.
1 Number of days when there was run-off ..	11	13	10
2 Total rainfall on days when there was run-off in either plot in inches.	9·16	15·66	15·66
3 Rain water lost in inches	4·00	7·52	3·29
4 Rain water lost as percentage of rainfall received.	43·67	48·01	21·01
5 Silt washed off in tons per acre	6·58	9·86	3·60
6 Silt washed off in tons per acre per inch rain lost.	1·65	1·31	1·09

It would be noted that in the control plot kept as clean fallow every inch of rain that is lost as run-off carried with it 1·5 tons of fine silt per acre per year during the two years. Some of the American results from Texas Experimental Station reported 3 tons of soil per acre for every inch of rain water lost. It was found that grass grown on the plots was 65 times more effective in the control of soil losses and five times more effective in checking water losses than bare soil. At the Agricultural Research Station, Nanjanad, run-off experiments since 1931 have indicated a similar

result that a grass cover checked the surface run-off to a considerable degree. When the gradient was doubled from one in ten to one in five the run-off losses were increased, nearly five times in all the plots except in the grass cover plot.

At the Dry Farming Station, Sholapur, Bombay State, it was found that a clean fallow plot lost 25 tons of soil in a year for a rainfall of 14·8 inches when the run-off was only 5·8 inches. This works out to 4·3 tons of soil per acre inch of run-off—a figure very much higher than that obtained at Hagari. A plot in which the weeds were kept on as cover showed a loss of only 0·58 ton per acre.

Violent thunderstorms cause a lot of erosion. For example, a single storm on the 28th and 29th September 1939 at Hagari was responsible for nearly a third of the total loss of silt for that year and nearly a fourth of the total loss of water for the whole year. It is stated that in Texas one heavy storm with a 5 inch rainfall led to the loss of 23 tons of rich black soil from land with a very slight slope.

Heavy soils shrink much on drying causing numerous deep cracks and fissures to be formed. In such a state, even a high precipitation does not lead to much loss by run-off as most of the water is absorbed through the cracks and hence run-off recorded early in the season are small and seldom exceed 15 per cent of the rainfall received.

The beneficial effect of scooping in reducing run-off and soil erosion is shown clearly in the following data from Hagari :—

Extract of run-off data (1938)—*Hagari.*

Date.	Rainfall in inches.	Run-off in inches. Control plot.	Run-off in inches. Scooped plot.	Silt lost in tons per acre. Control plot.	Silt lost in tons per acre. Scooped plot.
6th August 1938	1·89	1·12	0·26	1·259	0·409
18th August 1938	1·62	0·92	0·15	1·02	0·185
22nd August 1938	2·39	1·31	0·71	1·570	0·842
24th September 1938	1·18	0·60	0·03	0·492	0·036
25th September 1938	0·81	0·39	0·09	0·215	0·032
Total	7·89	4·34	1·24	4·556	1·504

The soil collected in the run-off cisterns when analysed for chemical and mechanical composition gave the following results :—

Mechanical analysis.

Head of analysis.	Run-off silt.	Soil first foot layer.
	PER CENT.	PER CENT.
(1) Clay	56·8	44·9
(2) Silt	26·9	17·1
(3) Fine sand	8·5	15·7
(4) Coarse sand	1·4	17·5

Chemical analysis.

Head of analysis.	Run-off silt.	Soil first foot layer.
	PER CENT.	PER CENT.
1 Loss on ignition	7·14	3·12
2 Insoluble mineral matter	63·95	75·49
3 Iron and alumina	20·95	13·19
4 Lime	3·83	3·45
5 Magnesia	1·52	0·92
6 Potash	1·28	0·29
7 Phosphoric acid	0·041	0·054
8 Nitrogen	0·043	0·024

The figures show that the silt washed off the land consists of about 84 per cent of the fine fraction while the original soil contained only 62 per cent. The nitrogen content of the silt is 0·043, while that of the original soil is only 0·024 per cent; further, potash in the silt is about four times that contained in the original soil. Much of the organic matter also gets lost, and thus from all accounts, the silt washed out of the land is much richer than the original soil. Unless, therefore, preventive measures are taken in time, there will be a gradual loss of fertility of the soil.

Control of erosion methods.—The main principle underlying the methods of soil erosion is to reduce the velocity of the flowing water. Methods of control may be classified as mechanical and biological.

Mechanical methods of control—Bunding.—This is done by means of an implement called the bund-former, designed by the department. It is a very simple labour-saving implement for forming bunds or ridges and can be used also in garden lands for forming beds for irrigation. In dry lands it can be used for forming bunds across slopes to prevent erosion after heavy rains and for conserving moisture. The implement which forms bunds, about 7 inches in height, can cover about 10 acres in a day, the cost of operating being about 4 to 6 annas per acre. The bunds which are formed before the rainy season get erased during the sowings. Therefore, bunding by the bund-former is an annual operation and in dry lands it is being advocated as part of the preparatory cultivation like working the 'Guntaka' or blade harrow. This operation is itself sufficient to arrest run-off in moderately sloping lands. But in greater slopes, and as a measure of permanent improvement, raising of embankment along contours, about 2 feet in height, is to be adopted. From the experience of the Bombay State, where these embankments are practised on an extensive scale, they have been found to be very effective in the control of erosion in slopy fields.

Listing or scooping.—A simple implement for forming scoops or basins in the field is the basin lister. It is essentially a furrower with an ex-centric cam arrangement. The implement which cuts a furrow in the land is lifted at regular intervals and dropped producing a series of cross-bunds to the furrow. These have the appearance of basins and hence the implement is known as the

basin lister. By thus throwing the land into pockets, the velocity of the run-off water is reduced and soil erosion prevented. From quantitative measurements at Hagari scooping has been found to reduce erosion losses by half, and in combination with the raising of embankments this operation should prove very effective against erosion.

Terracing.—Where the gradient of the cultivated fields is high, as on the hills, terracing and bunding are the methods generally adopted. Three types of terracing are recognized:

The guide-row terrace is formed by throwing a few furrows together on contour lines into a low ridge. The difference in altitude between successive ridges is about 3 feet. This is useful for slopes not exceeding one in ten.

The level bench.—This terrace consists of a series of benches or flat surfaces running along contours, the difference in altitude between one bench and another depending largely on the depth of soil available and the slope of the land. Each bench has to be cultivated as a separate unit and a good grass covering on the edge of the bund will considerably strengthen the terrace against erosion. The edges of the terrace have necessarily to be left uncultivated and this is one of the objections for its adoption on gentle slopes. But in hills, where cultivation is done in steep slopes, this form of terracing is very widely practised and is very efficient in controlling erosion.

Magnum terrace.—This is used very extensively in the United States of America and consist of a broad ridge 15 inches to 24 inches high, running along contours. It is formed by ploughing several furrows along previously surveyed lines and heaping the soil on the lower side so as to form a low ridge with a depression on the upper side of the ridge. Instead of the terrace being flat it is given a gentle gradient of about 6 inches in 100 feet towards some natural outlet into which the water may drain.

Gullying and its control.—Gully erosion, which is one of the most commonly occurring forms of erosion in open lands, can be tackled in the early stages, because it is an agricultural problem but in its late and more serious form, it becomes a problem for engineers to solve. In the early stages, the gully can be filled up by earth from some corner of the field or from an existing drain. Stones, straw or weeds may be used to fill up the gully, the material being such as would permit the easy flow of water, but would cause the soil to be deposited on the upper side of the obstruction.

For filling large gullies in cultivated fields, check dams constructed of stones and earthen packing may be used. A vertical tile drain, if provided, will considerably lengthen the life of the dam, as all the water will be drained out, thereby reducing the pressure on the dam itself. For larger gullies, concrete dams will be required.

Biological method of control.—Control of erosion through crops or vegetation is the biological method of control, since vegetation is nature's protection against erosion. As stated already, a cover of grass was found to be about five times as effective in controlling run-off, as a base soil and 65 times as effective in controlling soil losses. The principle of biological control is that cultivation of crops should be done in such a way that the maximum protection cover to the soil is offered for as long a period as possible, during the rainy season.

In the run-off plots at Hagari, the effect of a crop-like groundnut in controlling soil erosion was studied and some data from the experiment are given below :—

Results of run-off with catch crop, 1940–41.

(Data collected between 13th June 1940 and 12th December 1940, the dates of sowing and harvesting of groundnut, the catch crop tried.)

	Control plot clear fallow.	Groundnut plot.
1 Number of days when there was run-off ..	11	5
2 Total rainfall on days on which run-off was recorded in either plot.	7·63	7·63
3 Rain water lost in inches	2·81	1·63
4 Silt washed out in tons per acre	1·83	0·98

The number of days when there was run-off was 11 in the fallow plot, but only five in the groundnut plot. Losses of water and soil were also reduced by nearly 50 per cent by the crop. The effect of the cover crop has been three-fold, (1) interception of rainfall by the crop reduces the intensity of the rain-drops reaching the soil, (2) the spread of crop offers mechanical obstruction to the flow of water, and (3) absorption by the crop of part of the moisture reduces the soil to a drier state and makes it absorb more.

From studies based on the time taken for completely eroding a block of soil 40 inches by 20 inches by 4 inches under a definite pressure containing different cover crops, it was found that in resisting erosion, cotton was 1·6 times more efficient than bare soil, setaria 3·3 times, groundnut 5 times and pillipesara 11·8 times. Wide-spaced clean-tilled crops like cotton offer the least resistance to soil erosion whereas spreading close-spaced crops like groundnut, setaria and pillipesara serve to prevent soil erosion much more effectively.

Strip cropping furnishes one of the most effective biological methods of erosion control. The principle is that the strips of erosion-resisting crops like setaria, when alternated with stripes of cotton, serve to reduce the erosion that would occur if cotton alone was to be grown on the land. The prevailing local practice of growing setaria and cotton as a mixture in the *Mungari* season can well be replaced by this method of growing the same crops in

alternate strips. Six rows of setaria to three rows of cotton have been found to be the best proportion both for erosion, control and monetary returns.

Planting crops along contours is another anti-erosion methods, specially recommended for hilly lands. Generally contour planting in conjunction with contour cultivation go a long way in arresting run-off, though on very slopy land these should go hand in hand with terracing and bunding as well.

Planting agaves or similar dense, quick growing plants across the slopes liable to erosion will also prove helpful in checking soil erosion. At Adoni and along the banks of the Hagari river, *Prosopis juliflora* has been found to be very useful as wind breaks to prevent wind erosion.

Propaganda and anti-erosion measures.—A summary of the various directions along which erosion control has been attempted and achieved in Madras is given in the tabular statement at the end of this chapter.

The Madras Soil Conservation Scheme.--In view of the national importance of erosion control other countries like the United States of America are expending huge sums of money in the investigation and popularization of anti-erosion schemes. In India, Bombay was the first to initiate soil conservation schemes and Madras was the next in attempting to translate into large-scale practice the results obtained from dry farming research at Hagari and other centres. The Madras Soil Conservation Scheme was planned on the lines of a previous scheme in Bombay (the Contour Bunding Scheme) which had covered nearly nine million acres. The following are the anti-erosive measures proposed to be introduced under this scheme in the Ceded districts with the object of securing increased yields by proper land management :—

(1) Contour bunding.
(2) Contour trenching and afforestation.
(3) Gully-plugging.
(4) Terracing.
(5) Bunding with bund-former, basin listing.
(6) Contour cultivation.
(7) Strip cropping.
(8) Rotation of crops.
(9) Weed and pest control measures.
(10) Drainage and flood control measures.
(11) Manuring.
(12) Irrigation.

Among these, items of work like contour bunding, trenching, gully-plugging, terracing and diversion terraces for strip cropped areas will all be done by the Agricultural department as they have to be taken up in an entire catchment are or sub-water-shed as the ryots do not possess the technical knowledge or resources to do it

themselves. Agronomic measures like rotations, contour cultivation and strip cropping and manuring will be recommended for adoption by ryots.

The Government have also taken the requisite legislative measures to empower the Agricultural department to take up and carry out land improvement schemes in private lands and recover the entire cost or a portion of it from the land-owners in suitable instalments. The scheme was sanctioned in January 1949 with the requisite staff and the work has been started in three centres, Hagari, Alur and Guntakal with a target of 2,500 acres at each centre. A similar scheme is to be started in the near future in the Visakhapatnam district as well.

The progress of these schemes will no doubt be of great interest to the agriculturists of Madras as the systematic planning of such ameliorative measures will materially help in increasing food production in the State of Madras.

ALKALI LANDS AND THEIR RECLAMATION.

Alkali lands have always been a problem for the agriculturist who tries to bring them into cultivation. Alkali soils are formed first by the accumulation of salts in the region of crop roots. This accumulation may be either by the rise of salts from the deeper layers or by the use of irrigation water that contains a high percentage of soluble salts. The concentration of salts around the feeding zone of roots of crops hinders the growth of plants and makes these lands eventually unfit for cultivation.

Excess of soluble salts is the first stage in the formation of alkaline lands. The salts are chiefly the carbonates, bi-carbonates, chlorides and sulphates of calcium, magnesium and sodium. Of these, sodium salts are the most harmful, though beyond certain limits, magnesium salts also can prove injurious. Calcium salts are helpful and act as a safeguard against soil deterioration. The second stage is explainable in terms of the base exchange theory. The clay fraction of the soil consists of various types of colloids and various types of ions that are absorbed on the colloid surface, forming calcium clays, magnesium clays and sodium clays. Sodium clays deflocculate the soil particles into a highly dispersed condition and promote undesirable physical properties in the soil. This is what happens when the excess of soluble sodium salts referred to in the first stage becomes the exchangeable soda in the clay fraction of soil.

The third and final stage is associated with the formation of sodium carbonate and its hydrolysis, imparting highly alkaline reaction of the soil. When this stage is reached there is a complete deterioration of soil structure and the land becomes unfit for cultivation.

In Madras alkali soils are of widespread occurrence and although their actual area has not been estimated it is large enough to be

a serious problem. It was found from a State-wide survey conducted in 1917 that isolated alkaline patches of land are present in all parts of the State, except on the Hills and the Wynaad area where the heavy annual rainfall leach out salts from the soil. In the lower reaches of the Godavari and Krishna deltas especially in the Repalli taluk in Guntur district saline lands occur as also in the south of the Cauvery delta within the Cauvery-Mettur Project area. In the latter place the main difficulty is drainage owing to the low level of these lands. In the black soils of the Ceded districts saline patches occur even on moderate slopes as the parent rocks contain large quantity of sodium bearing minerals which on weathering give rise to sodium salts. As the tract is an arid one, these salts cannot get washed away but tend to accumulate, forming zones of salt concentration often within the root region of crops. In the Central and Southern districts saline patches are found as a result of irrigation from wells with brackish water. In Madurai district extensive areas of alkaline lands have developed under the Periyar irrigation system on account of poor drainage and the rise of sub-soil water.

Alkali reclamation—Early attempts.—These lands were the first to receive the attention of the Agricultural department for reclamation as they were under an irrigation project, the utility of which would be impaired by the development of alkalinity. In the earlier years the methods tried were those based on the traditional practices of the ryots in these areas and consisted of :

(1) Adding bulky organic manures like green leaf, green manures and farmyard manure.
(2) Carting and applying tank silt.
(3) Flooding to wash out the salts.
(4) Growing salt-resistant plants.

These methods were no doubt effective but the improvement in crop yields was very slow and not spectacular and hence did not become very popular with the ryots.

Reclamation methods based on soil chemistry were first tried on the Central Farm, Coimbatore, in 1936 in a field which had become very alkaline by irrigation from a brackish well. Soil analysis showed a very high pH value, and a high content of carbonates and bicarbonates. Sulphur was applied at the rate of 100 pounds per acre and within three months an appreciable reduction was observed in the pH value and the concentration of carbonate and bicarbonates in the soil. In the first season when a sorghum crop was grown the yield was poor but by 1939–40 normal crops could be raised in the field, where formerly only a very patchy growth was possible.

In the Tiruchirappalli district, there is a large area of alkaline land commanded by the Kattalai high level channel. This channel takes off from the Cauvery river at Mayanur and follows a course roughly parallel to the river. The area under irrigation lies

The Kattalai High Level Channel Area.

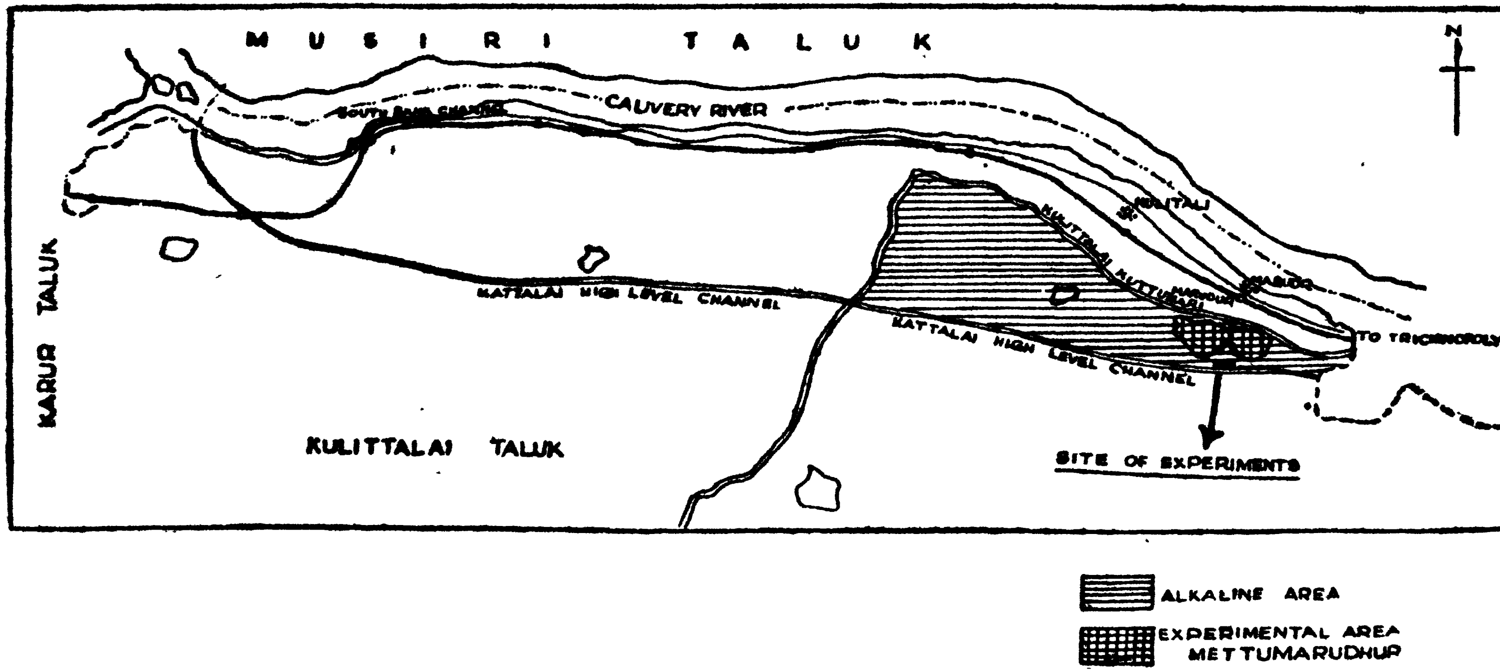


Plate 100

between this channel and the south bank of the Cauvery. Some of the low-lying lands in this area were saline and unproductive even before the advent of irrigation but the saline area increased after a few years of irrigation from this channel. In 1936 it was found that 2,500 acres out of the ayacut of 19,000 acres fixed for the channel, had become so saline that all attempts to grow crops were failures.

A preliminary survey was made by the Agricultural Chemist and showed that though the irrigation water did not contain any appreciable quantity of harmful salts, the drinage of the locality was very defective. The water table was so high as to be within two feet of the surface. The *Kulitalai Kattuvari*, a hill-stream that was intended as the main drainage channel for the area was found to be very shallow and prone to overflow its banks. To make matters even worse this channel had also dams put across it at some places with a view to utilise the water for irrigation purposes. It was, therefore, suggested that as a first step, these dams should be removed and the bed deepened.

The village of Mettu Marudur was selected for reclamation studies as being typical of the alkaline area. A white incrustation of salt covered the surface and barring a few palmyrah trees and some weeds there was no vegetation. Although the water available for irrigation in the high level channel was of very good quality practically free of injurious salts, rice crops had repeatedly been tried without success in this area. The seeds failed to germinate and seedlings raised in nurseries elsewhere and then transplanted withered away within a month's time.

When samples of soil were drawn and analysed from the first and second foot depths it was seen that there was a high content of soluble salts averaging 0·2 per cent and going up to more than one per cent in a few cases. No calcium salts were present, the salts being mostly the carbonate, bicarbonate, chloride and sulphate of sodium. The soils were very sticky when wet and almost impervious to water and were not only saline (due to excess of soluble sodium salts) but also alkaline due to excess of exchangeable sodium in the clay. The total exchange capacity varied from about 5 to 24 milliequivalents, but the degree of alkalisation was very high. The pH value of all samples was also high varying from 9·0 to 10·12. In view of this clear indication that soda clay had formed, with an almost complete destruction of the soil structure, amelioration by washing out the salts was out of the question.

Pot culture experiments were conducted at Coimbatore under controlled conditions, with soil collected from the alkaline areas, and various ameliorative treatments tried as given below:—

(1) Addition of farmyard manure at 80 tons per acre.

(2) Addition of gypsum at 4, 8 and 15 tons per acre.

(3) Addition of sulphuric acid, equivalent to 0·15 per cent and 0·30 per cent of sodium carbonate.

(4) Addition of sulphur at half and one ton per acre.

Plate 101.—Mettamarudur Land before reclamation

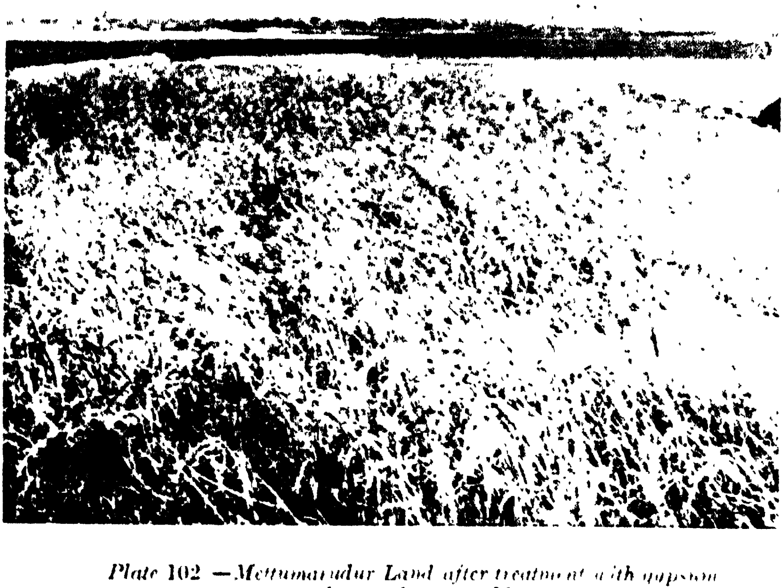


Plate 102.—Mettumarudur Land after treatment with gypsum with a good crop paddy.

(5) Addition of sulphur at half ton and farmyard manure at 80 tons per acre.

(6) Addition of molasses at 2, 4, 6 and 8 tons per acre.

Two of these treatments were cropped and the others kept for periodical examination of the physical properties of the soil.

These experiments and a similar set with rice seedlings transplanted indicated that with heavy doses of gypsum there was a remarkable improvement in the rate of permeability of water. Analysis showed a reduction in total soluble salts from 0·383 to 0·024 per cent, in exchangeable soda from 6·9 to one milliequivalent and from 10·28 to 8·45 in the pH value.

Based on these results experimental plots were laid out in Mettu Marudur village in a typically alkaline area. The plots were 7·5 cents each and the treatments included gypsum at ten tons per acre and sulphur at one and two tons per acre. Four control plots without any treatment were also included of which two were regularly flooded and drained like the treated plots, with the object of noting the effect of mere washing on the soil. Provision was also made for adequate drainage of these experimental plots. Soil samples were taken from all the plots in October 1937 prior to application of soil amendments and at definite intervals afterwards and analysed and they showed that within a period of three months, there was no trace of sodium carbonate in the gypsum treated plot though the original sample contained as much as 0·109 per cent. The analysis also indicated that in the sulphur treated plots biological oxidation of sulphur had made good progress in three months as evidenced by the reduction of sodium carbonate and the increase of sodium sulphate in the soil.

A green manure crop of daincha was then tried in these plots in June 1938. Germination was good in the gypsum plots, fair in the sulphur plots and failed altogether in the control plots that received no flooding. The crop was pulled out in October 1938 and showed that the gypsum plots gave the highest yield (1,830 lb. per plot) but even this yield was insufficient for the rice crop that was to follow. Green leaf was therefore added in sufficient quantities to make up to 500 lb. per plot and incorporated into the soil. *Sadai samba* seedlings were planted in October 1938 and harvested in February 1939. The control plot gave no yield at all as the seedlings withered away by December while from the gypsum treated plots an average yield of 1,050 lb. of grain and 1,450 lb. of straw per acre was obtained; quite a satisfactory outturn considering the original condition of the soil. A second crop of daincha sown in April 1939 gave a yield of 8,250 lb. per plot as against 1,830 lb. in the previous season from gypsum treated plots. A second crop of paddy planted in October 1939 and harvested in January 1940 gave a grain yield of 3,000 lb. per acre, thus proving the feasibility of reclaiming alkali lands within a period of two and a half years. These results also served to emphasise

the prime importance of drainage in all attempts to reclaim alkali lands.

Of the two methods outlined above, gypsum and sulphur, the latter is costly and not easily available to ryots, but gypsum exists as extensive natural deposits in the Perambalur taluk of Tiruchirappalli district. These deposits are now being utilised for cement manufacture but they can also be used for reclaiming the 2,500 acres of alkali land that is now lying as waste land. The Mettumarudar experiment showed that ten tons of gypsum per acre were adequate to give quick and striking results.

Reclamation of alkaline lands in arid areas.—Alkali lands in arid tracts are common in many parts of the world but in Madras such lands are fortunately very limited. One such area was in a village called Peddapalakalur about eight miles from Guntur where about ten acres of rainfed land were found to be unfit for cropping. Chemical analysis showed that in addition to a high percentage of soluble salts, the formation of soda clay had also progressed to a considerable degree. Being a rainfed area with no irrigation facilities, no gypsum treatment could be suggested and so the treatment here consisted in bunding the area into convenient sized plots, applying heavy doses of cattle manure at 40 tons per acre and soil mulching. Drains were cut around the treated plots to remove the salts dissolved by rain water. Experiments were started in 1944 and a green manure crop of daincha followed Pyru jonna (sorghum) in 1945–46 gave yields that indicated a distinct improvement in the condition of the soil. Chemical analysis also showed a decrease in salt content and in pH value.

Aziz Nagar.—In 1942 it was noted that the soils in the criminal tribes settlement at Aziz Nagar (South Arcot district) were turning alkaline. On investigation and analysis it was found that the the soil had a high content of soluble salts, particularly those of sodium and was in the first stage of alkalinity. As irrigation facilities were available, reclamation was suggested by flooding the land and draining off.

Vaipar area.—Along the coast in Tirunelveli district, there are flat saline waste lands bounded by the jungle stream Vaipar on one side and the sea on the other. There was an idea of reclaiming this area for colonisation by demobilised soldiers and analysis were made of soil samples from different depths. It was then found that the salinity was due to a high water table and since no sources of fresh water existed anywhere in the vicinity it was concluded that the reclamation of these lands was not a feasible proposition.

Natural reclamation of alkaline lands.—There is in South Arcot district a peculiar alkaline tract where it is claimed that while new alkali lands are being formed, old alkali lands are getting reclaimed naturally. This tract is 7 miles east of Vridhachalam in a stretch of land about 12 miles in extent sloping gently towards the plain from which water is drained off towards the sea on the east by *Parvanaru*. In the northern half of the plain there

is a perennial flow of underground water over about 1,000 acres of very good double crop lands extending over the villages of Mangalam, Elumichai and Uttargal. In the midst of this wet land area is a screwpine jungle of 15–20 acres, near which the soil is so soft that cattle get bogged in it and ploughing is never attempted. The alkaline lands are in the Ichangod block comprising nearly 700 acres in isolated patches. There are several hundreds of these almost circular in shape, 6–20 feet in diameter and lying at various distances from one another. Their formation is as given below :—

The first stage is a white-coloured patch with concave surface from which water oozes out and collects in the hollow. This water is brown in colour and alkaline in reaction. In dry weather this forms an incrustation which is sometimes scraped and used by washermen for washing clothes. The whole patch is soft and miry and no man or beast can walk on it without sinking in. There is no vegetation of any kind on these patches. The next stage is an upheaval, the soil being thrown out into a convex heap. A friable black soil is left on the surface mixed with *kankar* or lime nodules. Below this heap the soil is still soft and slimy for a depth of 5 or 6 feet below which the soil is comparatively hard and compact. When a sampling rod is inserted into this miry layer and withdrawn a rumbling noise is heard as of confined gases escaping. The upheaval goes on presumably for years with kankar nodules getting bigger and bigger each time. There is no vegetation at this stage also.

The third stage is the stage of natural reclamation. After several years' upheavals there is again a slight depression but now the soil is firm and quite safe to walk upon. Mosses and other low forms of vegetation grow in this depression and decay and on this vegetable debris coarse grasses and various weeds flourish in course of time.

The last stage is marked by complete reclamation, good grass grows luxuriantly and the area becomes the grazing ground of the adjacent villages. The cattle grazing here, however, avoid the boggy patches as it was by instinct. Date palms begin to flourish and in some of the larger depressions, coarse rice also is grown sometimes.

On investigation it was found that the soft and slimy soil contained soluble organic matter. soluble sodium salts, chiefly sodium carbonate and a high percentage of calcium carbonate. The calcium carbonate cannot interact with sodium salts, because unlike gypsum it is almost insoluble in water. Thus the soluble sodium carbonate slowly moves to the surface and converts the soil into a morass. In course of time the organic matter in the soil decomposes with gas formation. Ordinarily these gases cannot overcome the resistance of the soft and slimy layer but when the gases accumulate to a sufficient degree, they force themselves out,

bringing up the soil in a heap. From this soil, the sodium carbonate slowly diffuses out downwards leaving the calcium carbonate on the surface as the soil dried up. In course of time the *kankar* or calcium carbonate particles get larger and give a friable texture to the soil. The rumbling noises heard are due to the escaping gases.

Where there are reserves of calcium salts as in this area natural reclamation of alkali land can take place under favourable conditions. Further, organic matter, by its decomposition, gives rise to products which aid both physically and chemically in the reclamation of alkali land. The incorporation of bulky organic matter like green leaf and green manure crops which has been advocated by the Agricultural department finds justification in this instance of natural reclamation of alkali lands in South Arcot district.

SOIL ORGANIC MATTER AND ITS DECOMPOSITION.

Every farmer is aware of the benefits of organic matter in improving the fertility of his soils. What is not so well known is that organic matter as such does not confer any lasting benefit unless it is first converted into what is known as humus. Organic matter gets converted into humus only under certain conditions. These conditions have been studied in great detail in various parts of the world with the object of being able to provide the most optimum conditions for the rapid and efficient conversion of organic matter into humus.

In Madras, studies on the decomposition of organic matter have been carried out on the following aspects. The incorporation of green manure of different kinds, under different conditions such as dry land, garden land and wet land conditions was one line. The addition of molasses and the changes brought about thereby was another study. Another line of investigation was the production of nitrates under garden land conditions, their movement in the soil and their utilisation by the crop.

Decomposition of green manures.—For these studies soil samples from dry black soils, irrigated black soils and red soils obtained from various Agricultural Research Stations were made use of in pot culture studies at Coimbatore. To begin with certain analytical methods were standardized and the organic matter in the soil was attempted to be partitioned as mineral, total and organic carbon.

One set of experiments was an attempt to study the organic matter content and the carbon/nitrogen ratio in the black soils under irrigation as this knowledge would be useful in advising the ryots in the Tungabhadra project area. The experiments were laid out at the Agricultural Research Station, Siruguppa, with plots under irrigation in which known quantities of green manure were incorporated. It was found that an application up to 8,000 lb. of green manure per acre did not have any effect but with 12,000 lb. per acre, a very slight improvement in organic matter content was noticeable. Another set of experiments on the garden land soils at

Anakapalle Agricultural Research Station showed that a green manure application at 3,000 lb. per acre per year continuously for 25 years had not increased the humus content of the soil, thus proving that the present rates of applying green manures to our tropical soils are at best sufficient only for maintaining the *status quo* without depleting the soil of organic matter still further.

In another set of pot culture experiments in 1943 the different fractions of organic matter and nitrogen from added materials to the soil were estimated. The materials used were sunnhemp, groundnut cake and rice straw. The object of the experiment was to study the possibility of improving the organic matter and nitrogen content in irrigated black soil. It was found that when the ratio in the added materials of lignin and cellulose to the proteid was kept at 3 : 1 or 4 : 1, this result could be achieved. It was also noticed that the addition of small quantities of superphosphate was helpful probably because a supply of readily available phosphoric acid was helpful to the bacteria responsible for the breaking down of organic matter into humus.

Green manure decomposition under swamp wet land conditions.—The decomposition of green manure under wet land conditions was studied in great detail during 1917—1920. These studies have thrown much light on the nature of the decomposition and other changes that green manures undergo when applied to swamp rice soils. Normal fermentation of green manure in wet land rice soils lead to the production of relatively large proportion of methane in the gases that are evolved during decomposition together with some carbon dioxide and hydrogen. This process is what occurs when no crop is on the land. When a crop is present, the formation of methane, hydrogen and nitrogen is restricted. The soil conditions in a normal rice field are anærobic making nitrification impossible and hence it was concluded that the nitrogen required by the rice crop is obtained from the ammonia and other nitrogenous organic compounds produced by the anærobic decomposition of the green manure. In the early stages of decomposition of this green manure toxic products are produced and unless these are removed in the drainage water or further modified by prolonged decomposition before the seedlings are planted, the crop is likely to suffer.

In the course of this investigation it was noticed that the algal film that was formed on the surface of rice soils made use of the gases evolved from green manure decomposition, in such a manner as to bring about an increased oxygen output. This film further contains bacteria that are able to exidise methane and assimilate directly both methane and carbon dioxide. These reactions finally result in the evolution of oxygen. Thus the algal film aids in increasing the oxygen concentration of the puddle in rice fields and the practice of green manuring increases the output of soil gases and thereby increases oxygen production and root aeration. On the basis of this finding, it would appear that the beneficial effect of green manure in rice fields is more due to the increased

aeration of the roots than to the nitrogen that is made available for the crop.

In 1930 this problem was investigated again under pot culture conditions. The role and efficacy of the algal film in promoting root aeration were verified and confirmed but there was also an indication that the nitrogen of the green manure was not lost and that the large volume of nitrogen observed under fallow conditions was probably derived from the atmosphere. From similar investigations in Ceylon it is reported that the effect of green manure is not merely indirect as aiding root aeration but also direct as a manure supplying nitrogen to the crop. A considerable amount of ammonia is produced during the decomposition of green manure and is utilised by the rice crop. To settle this point, pot culture studies were carried out at Coimbatore, with green manure, ammonium sulphate and control treatments. It was then found that ammonia was actually produced during the decomposition of green manure but that all of it was not recovered in the drainage water indicating that ammonia is either retained in the soil or utilised by the rice crop. This makes it clear that in addition to providing root aeration, green manure by its decomposition in swampy conditions also makes nitrogen available to rice plants.

Nitrification of soils.—Except in the case of a few plants like rice, plants generally absorb nitrogen only in the form of nitrates and the conditions under which organic nitrogen is converted into nitrate nitrogen have received wide attention. Both nitrification and its reverse process denitrification are due to bacterial action and bacteriological investigations were taken up at Coimbatore during 1923–24. The nitrification of groundnut cake, with and without application of lime, at varying moisture levels, was studied on two types of soils, black cotton soil and garden land red soil of Coimbatore; and it was observed that lime tended to increase the optimum moisture content for nitrification in the garden-land soil. Nitrification was found to be more rapid in the black soil than in red under the laboratory conditions in which these studies were carried out. In the black soils of the Central Farm, Coimbatore, the rapidity of nitrification was in this order; groundnut cake, castor cake, Pungam cake, *ganja cake*, fish guano and horn meal. On the red soils, ganja cake was the most easily nitrified, followed by groundnut cake. Judged by the yield of grain and straw in pot culture studies groundnut cake gave the best result and was distinctly superior even to ammonium sulphate.

During the period 1936–40 a set of experiments were laid under field conditions to ascertain how soon green manure and other bulky organic manures would nitrify when ploughed into the soil in July and how far the resulting nitrate would become available for the cotton crop in the month of October-November. The manures tried were cattle manure, green manure and ammonium sulphate. Under field conditions ammonium sulphate was the quickest to nitrify the next being green manure with cattle manure as the slowest. The relative nitrification in these was of the order

of 100 per cent, 50 per cent and 25 per cent, respectively. A primary nitrification takes place eight to ten weeks after the manures are applied and ploughed in and a secondary nitrification about six months later. The rate of nitrification is governed primarily by moisture conditions in the soil, a moisture content of 20 per cent being the optimum for maximum efficiency of nitrification. Under actual field conditions, however, the yields of cotton indicated that nitrogen was absorbed best from the cattle manure plot, least in ammonium sulphate and intermediate in the green manure plot, the cattle manure plot giving the highest yield of kapas as well as total dry matter. It has, therefore, to be concluded that nitrogen added in the form of ammonium sulphate is not fully utilised by the crop. Laboratory examination of the deeper layers of soil showed that there was no downward movement of nitrate indicating that the nitrate should have got converted into insoluble proteids by micro-organisms. The presence or absence of organic matter and the equilibrium ratio of carbon to nitrogen influence this loss by conversion into insoluble forms. The carbon nitrogen ratio of cattle manure was 16 : 1, that of green manure 10 : 1, while ammonium sulphate was devoid of any carbon and was all nitrogenous.

The comparative values of different green manures have been determined and are summarised in tabular form furnished at the end of this chapter.

Decomposition of molasses in paddy soil.—With a number of sugar factories in the country, lerge quantities of molasses are available at present for which there is no satisfactory outlet, although from time to time a number of possible uses have been suggested and attempted. The manufacture of power alcohol, food yeast, use as road binding material are some of the possible uses and in addition to these it has also been claimed that application of molasses corrects alkalinity in the soil. To see how far this claim is true, a set of experiment was laid out in 1934–1937 in the wet lands of the Central Farm at Coimbatore to study the decomposition of molasses and see how far it was beneficial in increasing crop yields or correcting alkalinity. The first observation was that application of molasses in rice soils retarded biological activity during the first fortnight. Sugars disappeared within 24 hours with the evolution of gases like carbon dioxide, hydrogen, oxygen and methane. No nitrogen was detectable. There was a rapid increase in lactic acid up to ten days followed by a gradual decrease thereafter. The general conclusion that was arrived at was that when molasses are applied to soils it is fermented rapidly with an evolution of organic acids. These acids are subsequently broken down, leaving the organic matter content at more or less the same level as in the beginning. No increase in crop yields or any improvement in the chemical, physical or biological properties of the soil could be observed as a result of applying molasses either on garden land or in wet land. A dosage of five tons per acre decreased the yield of paddy, and higher doses gave no increases

and the experiments proved that molasses cannot be utilized as a source of increasing the organic matter in Madras soils.

SOIL CONDITIONS AS AFFECTED BY CROPPING, CULTARAL AND MANURIAL TREATMENTS.

In the Godavari and Tanjore deltas it is the usual practice to leave the land fallow during summer without any cultivation and take up puddling only after receipt of water in the canals. This practice has always given a good yield of rice. In the Godavari delta when attempts were made to grow sugarcane oftener than once in three years as in the usual rotation, necessitating the ploughing or crow-barring of the land after paddy harvest, it resulted in the land losing condition, and giving very poor yields. Similarly in Tanjore, the effect of a summer ploughing of wet lands has been to depress the paddy yield that season. In both these deltaic areas ploughing the land in summer destroys the crumb structure of the soil and makes percolation of water difficult and very tenacious when wet. This serves to show that where a particular cultural practice is in vogue in a particular locality or a specific type of soil, it should not be altered without a proper study of the possibilities of a change in soil structure thereby.

Soil condition and manuring.—An investigation was carried out at Coimbatore on the suitability of sodium nitrate for rice lands and showed that soda entered into the clay complex with an adverse effect on the physical properties of the soil. This deleterious effect was mitigated by the addition of adequate green manures with a plentiful supply of water.

Soil condition and cropping.—In the black soils of Thirunelveli and Ramanathapuram districts there is what is known as the "Cholam effect" where the yield of any crop that follows a sorghum crop is found to be poorer in yield by about 15 per cent than when the same crop is grown after a Bajra crop or a cotton crop. An investigation was carried on this problem at the Koilpatti Agricultural Research Station during 1934 to 1937. The agronomic aspect of this investigation comprised various treatments, such as manuring, spacing, different seed rates, trial of alternate fodder crops in place of "Irungu" sorghum, application of lime, etc. The chemical aspect of the investigation included a study of the nature and extent of soil colloids as influenced by cropping with sorghum. It was found that a change occurred in the exchangeable soda content of the soil, as an after-effect of growing a fodder crop of sorghum. Analysis of soils at various intervals during crop growth showed that in both sorghum and bajra plots, exchangeable sodium increased progressively from October onwards, until the crop was harvested in February. There was also a similar increase in the colloid content of the top layer of soil during crop growth. This progressive increase was, however, greater in the sorghum plot than in the bajra plot. It was concluded that the "rise of soda" in the bajra plot had not reached toxic levels

whereas with the sorghum crop, which had a longer duration of one month more than bajra, the rise of soda attained a toxic level. The actual figures were 3·86 to 8·96 milli equivalents in the case of bajra plot and 3·94 to 11·14 milli equivalents in the case of sorghum plots. Soils were prepared in the laboratory containing different amounts of exchangeable soda, from 3·0 to 11·0 milli-equivalents. Cotton seedlings grown on these prepared soils grew well, up to 8·0 milli equivalents but with higher levels of soda the roots could not develop properly. It was hence inferred that the greater rise of soda in the "after-cholam" soils is responsible for the harmful effects. When the sorghum crop was in the shot blade, the content of exchangeable soda was the same as in bajra plots and agronomic experiments showed that if the fodder sorghum was cut at shot blade the succeeding cotton crop was not depressed in yield. This suggested that a solution to the problem was possible by harvesting the sorghum at the shot blade stage itself, instead of allowing it to stand in the field for one month longer for setting seed. This might result in a somewhat poorer yield of fodder for the area but would result in a better yield of cotton which is more profitable.

It was not possible within the specified period allotted for this investigation to follow up these findings nor to arrive at a satisfactory explanation of the process by which the soil gets corrected by mere lapse of time after a fallow or after a crop of bajra. The problem of the deleterious after-effects of sorghum continues, however, to attract attention in other parts of the country. Many theories have been put forward but convincing experimental evidence is lacking. In view of the importance of this problem, the Indian Council of Agricultural Research has recently sanctioned a research scheme on this problem and the progress and results will be watched with interest.

Soil conditions and cropping—Betel-vine.—Following a complaint that the betel-vine crop in the gardens along the *Noyyal* river banks in Coimbatore were badly damaged by a disease, the "Karunthal" disease, an investigation was carried out in 1924 at a place called Vellalur, 3 miles to the east of Podanur junction, jointly by the Agricultural Chemist, the Mycologist and the Entomologist.

The chief feature of betel-vine cultivation in this tract was the extreme water-logged nature of the soil. The fields were clayey and also in close proximity to the channels of the Noyyal river and it was not unusual during the monsoon months to see the fields submerged under water. Betel-vines are, as a rule, planted on either side of raised ridges at the base of *Agathi* (*Sesbania grandiflora* Pers), plants which serve as props or standards and the rows of which are arched at the top to form a sort of shady bower. The trenches in between the ridges get deeper as the betel garden gets older as the soil is dug up and earthed up on the vines growing on these ridges.

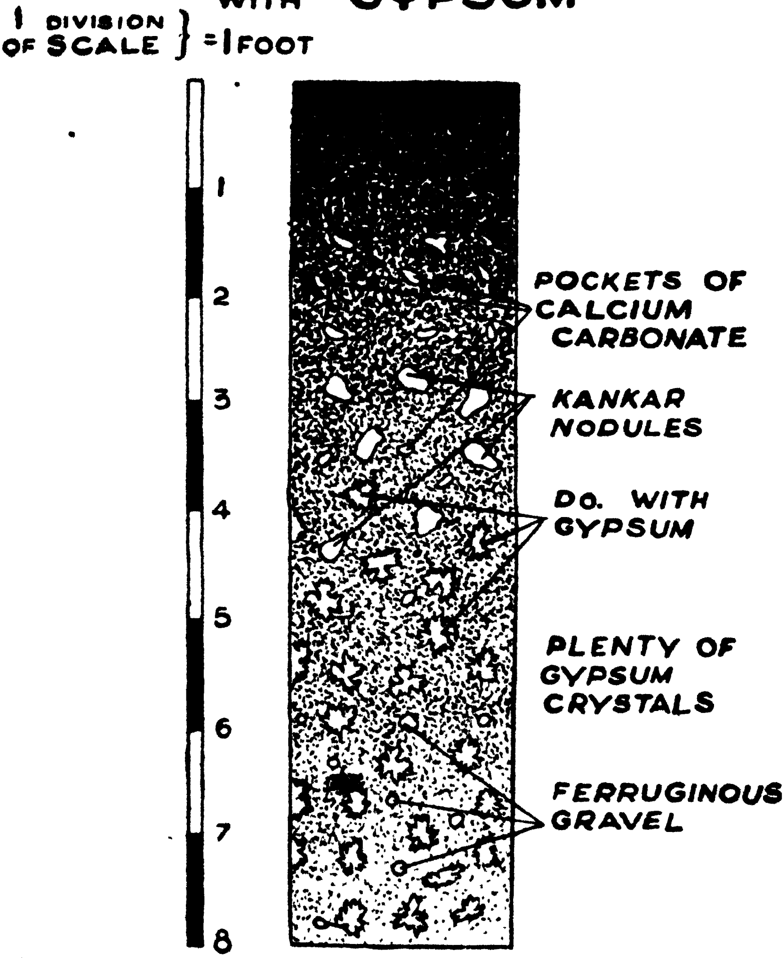
On diagnosing the primary factor as lack of drainage, the ridges were raised to 2 feet more than in the local practice and the yield figures compared with an untreated area. An improvement of 20 to 55 per cent was observed in total yield, the highest increase being obtained in May–July when normally the crop is yielding its maximum.

Along with these treatments the effect of manures was also studied, chiefly with the object of testing the popular belief of the local growers that earthworms were the real cause of betel-vine damage. By growing the vines in rows manured with mineral mixtures like potassium nitrate and superphosphate the chances for earthworm were sought to be minimised, since earthworms need a lot of organic matter. The effect on yields of mineral mixtures and of organic manures were compared month by month. A survey of the earthworm population also was done periodically by the Entomologist. In addition, lime was used in another experiment as an addition to improving the drainage to prevent attack by fungal diseases. The yield data showed that liming increased yields, and that organic manures gave the high yields and better quality leaves than mineral manures. It was also noted that the quality of leaves was invariably better on the vines grown on raised ridges as compared to the local type of ridges. Raised ridges gave healthy leaves while local ridges gave diseased leaves.

It was thus established that defective soil conditions were the factors primarily responsible for the falling off of yield and quality of betel leaves, for which an improvement in drainage was the most effective remedy. The system of tenure that obtains in these gardens is also partly responsible for the trouble, as the tenant in a six-year lease tries to get as much profit as possible by continuous cropping with betel-vine and sugarcane as a result of which the land gets water-logged without any chance for proper aeration or weathering. A periodical fallow would help a great deal in ameliorating the condition in these gardens.

Earthworms and fertility.—The study of earthworm population and an analysis of earthworm castings during the course of this research scheme between 1925—30 revealed the following points:—(1) Earthworm castings are rich in mineral constitutents in a more easily available form than those present in the ordinary soil; (2) application of lime or mineral fertilizers decrease the population of earthworms, while organic manures increase their population; (3) there was no evidence that earthworms were harmful for betel-vine growth since the organic matter consumed by them was returned as castings. Earthworms may be considered as natural tillers of the soil and friends of the farmer. It is estimated that nearly 10 tons of worm casts are brought up to the surface in each acre of land in a humid region well supplied with organic matter raising the level of the land by 1 inch in ten years' time. In Madras earthworm activity is very much in evidence in rice fields especially in the Tambraparni basin in the Thirunelveli district.

DEEP BLACK COTTON SOIL WITH GYPSUM



Fundamental Studies on Soils.

It would be clear from the foregoing account that much of the work done by the Agricultural Chemistry Section, in the matter of soil surveys, irrigation projects, alkali reclamation and soil amendments of various kinds, has all been based upon the funda mental knowledge gathered on the soils of Madras, both in the field and in the laboratory. Among these fundamental studies, the work done on the origin and geo-chemistry of Madras soils deserve special mention. The earliest work was on the colour of the black cotton soils and the results pointed to the conclusion that the colour was due to the presence of organic matter or the presence of a black mineral common to these soils. It was assumed in these early investigations that the results of a study made on black soils in Central India would also be applicable to black soils in Madras. Thus Annett, working in Madhya Pradesh, had come to the conclusion that the colour in black soils was mainly due to the presence of titaniferous magnetite and 1 to 2 per cent of soluble humus. The majority of the samples examined by this worker was from Bombay and Madhya Pradesh and only one sample from Samalkota was examined to represent Madras soils.

When Harrison and Sivan applied Annett's method examination was applied to typical soils of Madras State the black soils of Bellary, Kurnool, Guntur and Thirunelveli districts, they found no evidence was found of magnetite material indicating that these soils were different from those of the Madhya Pradesh and Bombay. A more detailed investigation was, therefore, taken up commencing from the collection of soil samples from different regions and areas with full notes on the sub-soils and underlying rock formations. A preliminary grouping was made on the following lines :—

Tirunelveli-Ramanathapuram area.—The underlying rock was granitoid gneiss, usually garnetiferous but sometimes with a preponderance of mica. In the water courses, pink, transparent, crystalline grains of garnet were found.

Bellary area.—These soils generally rest upon *Kankar* beds with granitoid gneiss below and was distinguished from the Tirunelveli by the absence of garnet grains.

Guntur area.—Overlying metamorphic rocks. Here the soil rested upon red gravel which, in turn, overlies weathered material derived from granitoid gneiss, chiefly micaceous in character.

Soils of the Kurnool area.—These soils, especially in the Koilkuntla taluk, are the best among the black soils of the State. They differ from other areas in that shales and limestones were found underneath. The deepest black colour associated with black soils is found in this area and there is a general belief that the darker the soil, the more suited it is for cotton.

Soils of the Palnad area in Guntur district.—Similar to the Koilkuntla type, these soils also are rich in calcium carbonate which sometimes reaches a value of 20 to 23 per cent. The sand obtained from these soils contain a large proportion of black limestone.

DEEP RED SOIL

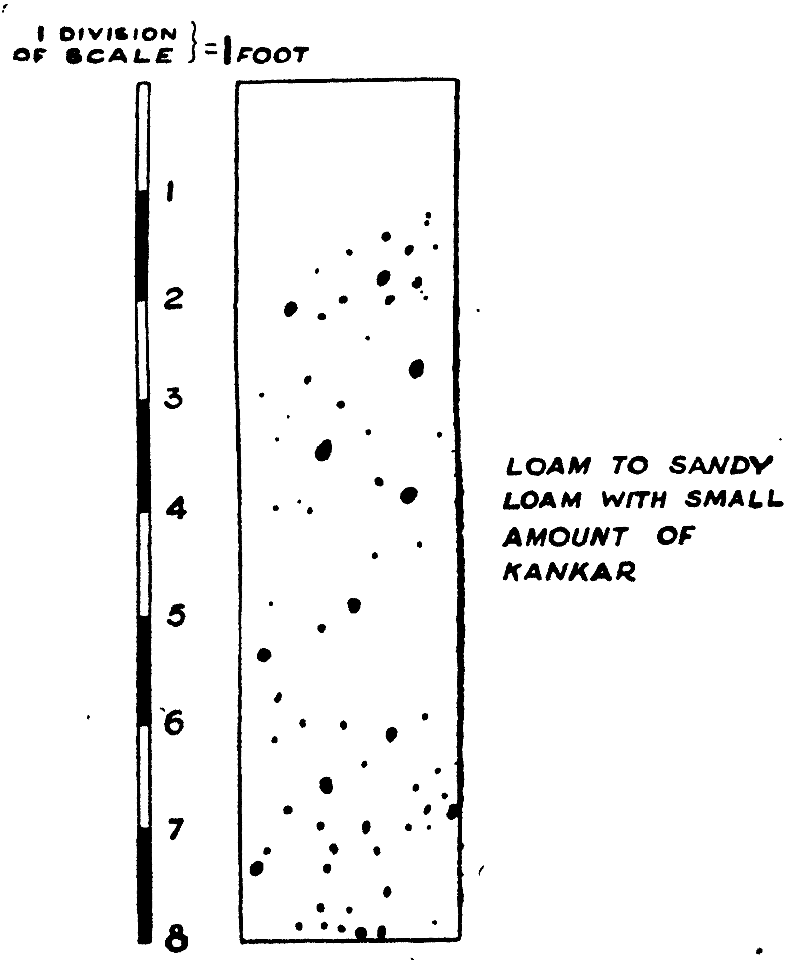


Plate 104

Following Annett's work, the soil samples were examined for minerals with specific gravity over 3·2 and for the percentage of magnetic particles in this fraction. A ratio of the percentage of magnetic to the non-magnetic was worked out and the results of this examination are tabulated below :—

Serial number and places.	Percentage of particles with specific gravity greater than 3·2.	Percentage of particles of magnetic nature and specific gravity more than 3·2.	Ratio—Percentage magnetic/percentage non-magnetic.
Soils from—			
1 Tirunelveli and Ramanathapuram districts	1·029	0·012	1/85
2 Bellary district, lying over metamorphic rocks	0·362	0·022	1/15
3 Guntur, over metamorphic rocks..	0·397	0·030	1/12
4 Nandyal valley	0·216	0·017	1/12
5 Palnad taluk, Guntur district ..	0·01	0·01	..

This examination indicated that it is possible to divide the regur soils of Madras into several types depending upon : (1) percentage of particles of high specific gravity, (2) percentage of heavy magnetic particles and (3) proportion of the heavy magnetic particles to the heavy non-magnetic particles. In addition, a microscopical examination of particles with specific gravity over 3·2 was made. It was seen that the minerals present in a soil were distinctly related to those of the underlying formation. Thus the soils of Tirunelveli contain a preponderance of garnets, of Bellary synthetic minerals while those of Guntur were micaceous. This relationship between soil minerals and those of the underlying rocks pointed to the conclusion that although possessing common agricultural characteristics, and were, therefore, loosely included in one group these soils are derived from many diverse rock formations and that they are of comparatively local formation.

Along with a study of these Madras samples, samples of black cotton soil from other States were also obtained. These were from Bombay and Madhya Pradesh and were all samples collected in places where the underlying geological formation was the Deccan Trap. Another set of samples was alluvial soils derived from Trap rocks. The results obtained from these samples are given below :—

Serial number and place.	Percentage of particles with specific gravity greater than 3·2.	Percentage of magnetic particles of specific gravity greater than 3·2.	Ratio per cent magnetic/per cent non-magnetic.
1 Soils overlying trap rock from Bombay and Madhya Pradesh—Average of 11 samples	3·06	1·02	1/2
2 Alluvial soils derived from trap rocks—Average of seven samples, five of these from Bombay and two from Madras, Vijayawada and Samalkota.	2·29	0·79	1/2

It will be seen that soils with trap rock underneath and alluvial soils formed from rivers flowing through trap rock formation, have a very much higher proportion of heavy particles than all the soils from the different areas examined in Madras. The proportion of magnetic particles is also higher. While therefore titaniferous magnetite was looked upon as the substance which gives the chaacteristic colour with regard to the trap soils, its absence in the Madras soils indicates that the real factor responsible for the black colour is something else.

The next step in the investigation was to determine the nature of this colouring matter that was common to all the black soils of Madras. An experimental method was devised based upon the separation of soil particles into various fractions according to their specific gravity as given below ;—

First—Heavy fraction particles—small in quantity.

Second—Silicates and sand usually white—large in quantity.

Third and fourth—Similar to the second fractions but smaller in quantity.

Fifth—Large in quantity, dark coloured with a very low specific gravity.

This fractionation showed that the fifth dark fraction was common to all the *regur* soils, whatever their derivation and to this should be attributed the dark colour of these soils. Microscopic examination revealed that this fraction was composed of compound particles of a transparent or semi-transparent material held together by a dark-coloured cementing substance. This cementing substance was colloidal in nature and very stable. After prolonged digestion with hot sulphuric acid and microscopical examination it was concluded that this cementing substance was an amorphous silicate. Evidence was also secured that there was a small portion of organic matter in combination with this silicate. In the case of Palnad soils from Guntur with a high content of calcium carbonate, the fifth fraction of dark-coloured particles was high when the fractionation was done without any previous treatment with acid but when the experiment was repeated after decomposing the carbonate with hydrochloric acid, this fraction was reduced to nearly one-third the quantity accompanied by a distinct change in colour from black to buff.

The conclusions from this investigation can now be summarised as below :—

(1) The black cotton soils of India are derived from a variety of geological formations.

(2) When not alluvial in origin, these soils bear a close relationship to the parent rocks.

(3) Titaniferous magnetite is not a constant factor in the *regur* soils in Madras State. Even when occasionally found the amount is small.

Its occurrence in quantity is characteristic of the *regur* soils of the Deccan Trap formation area.

The characteristic blackish colour and physical properties of black soils are associated with compound particles of low specific gravity; these particles being composed of a cementing material which is a colloidal hydrated double silicate of iron and aluminium and confers the black colour and physical properties to the soil and an organic portion, which has also iron and aluminium in combination.

Soil profiles—Origin of the central farm soils—at Coimbatore. —One of the first attempts to utilize the modern concepts of soil profiles in tracing the derivation of soils, was with reference to the soils of the Central Farm, Coimbatore, in 1930. On these soils there was a distinct zone of *kankar* or limestone nodules of varying thickness below the 'A' horizon indicating that the soils must have been formed by transportation from elsewhere. By further observations on the topographical and other features it was inferred that the agency of transport must have been rainfall.

Origin of soil types of Madras Deccan.—In the course of the Tungabhadra project survey it was noted that while the black soils extended over the larger portion of the area, the red soils were distributed like islands in a sea of black soil. There was no gradual merging of the black into the red soil areas or vice versa, but on the other hand, there was a sharp demarcation between black and red. Various theories had been advanced to account for this adjacent disposition of black and red soil areas within the same tract. One of these was the theory that both red and black soils should have been derived from the same parent rock, the difference being determined by the topography. According to this view the red soil was the first formed and from them the black soil was transported later on adducing in support the fact that red soil was found on hill tops and higher slopes while black soil was found in the depressions and valleys. But it was found that black soils also occurred in certain places at an elevation of 1,500 feet and more and red soils over extensive stretches in valleys and hollows so that it was difficult to accept the view that black soils were alluvial in origin and red soils non-alluvial. Further the climatic conditions of the tract had been in the same stable state over the whole of the tract since very early times. Hence a new hypothesis was suggested that there must be a difference in the genetic origin of the two types of soils and the wealth of soil samples collected in the course of the Tungabhadra Project Survey and the detailed descriptions of soil profiles was utilized to see if this theory could be substantiated. A detailed examination of the clay fractions from black and red soils was made on these samples with special reference to the silica-sesquioxide molar ratio in the two soil hypes. In black soils the clay fraction had a uniform silica-sesquioxide molar ratio of three, while the red soil was poor in clay content and the value of the ratio in this clay never exceeded

two. Again the black soils contained in their silicate complex 6 to 12 per cent lime and magnesia whereas the red soils had little or nothing of these two constituents. Both black and red soils had about the same amounts of iron. Further work showed that a high silica-sesquioxide ratio and high content of lime and magnesia in the clay complex were not in themselves the cause of the black colour in black cotton soils but that such a composition gives clay of light grey colour which in combination with even small amounts of organic matter develops the characteristic black colour. This was proved by destroying the organic matter in these soils without affecting much of the inorganic clay complex by means of hydrogen peroxide. It was found that when black soils were treated with hydrogen peroxide after pre-treatment with hydrochloric acid the black colour was destroyed.

As a result of these studies some evidence was also secured on the origin of black and red soils. Both types are likely to have been formed *in situ*; their chemical composition being related to the mineralogical composition of the parent rock. The rocks common in the area are granites and gneisses and it was noticed that red soils occurred in the vicinity of rocks having a predominance of alkali felspars while the black soils were associated with hornblende schists, trap dykes, highly basic gabbros and with limestones of the Vindhyan age. All these pointed to the fact that black soils were formed presumably from rocks rich in calcium and magnesium while red soils were derived from rocks low in calcium and magnesium but high in potash.

Geo-chemistry of Madras Deccan Soils.—As a continuation of the foregoing work on the origin of black soils and red soils, a scientific study of the soil as a unit by itself was carried out at Coimbatore making use of the extensive series of soil samples and profile descriptions from the Tungabhadra Project Survey This study was along four lines, morphology, dynamics, minerological composition and clay complex minerals. The morphology studies included a detailed analysis of the several horizons in soil profiles with a view to classify them on genetic lines, on the model of work on soil types in other parts of the world. Based upon their external profile features, the black soils of Madras Deccan could be compared to the other black soils of the world like the " Chernozems " of Russia and the black prairies of North America. The absence of the ' B ' horizon in the black soils of Madras Deccan and the presence of calcium carbonate in all the profiles and of gypsum in some profiles showed that these black soils are similar to the typical chernozems, the only distinction being that while the ' C ' horizon in Madras is granitic in nature the ' C ' horizon in chernozems is the loesslike parent material developed under a climate characterised by a low annual precipitation. Madras soils are not sufficiently leached out as is shown by the considerable amounts of calcium carbonates. They are thus different from thhe black prairies of North America which have developed under higher

rainfall conditions and have a clearly marked 'B' horizon. The Madras Deccan black soils are further distinguished from the Chernozems by the absence of "crotovinas" by a low humus content, by a low degree of leaching and by considerable alluviation of the finer fractions in the profile.

In the earlier years the black soils of Madras Deccan on account of their apparent similarity used to be grouped along with the Russian chernozems and it was only after these geo-chemical studies were carried out in 1940–41 that it was established that though there were morphological similarities there were also fundamental differences between the two types of black soils.

As regards the red soils of Madras Deccan the profiles were characterised by more distinct differentiation into A, B and C horizons. In other parts of the world red soils are met with under either podsolic or laterite conditions. The podsolic red soils are characterised by a bleached grey 'A' horizon which was not found in the Madras Deccan red soil profiles and hence these could not have been formed under podsolic conditions. In the laterite red soils—in other parts of the world, the natural development is the 'B', 'A' and 'C' types or horizons whereas in the Madras Deccan red soils, the horizon types were 'A', 'B' and 'C'. Further the 'C' horizon in Madras red soils was weathered granite and contained no calcium carbonate, thus differing from the red soills found along the Mediterranean coast. A detailed examination of various red soil types of the world revealed a close relationship between Madras red soils and the granite sandy loam of South-East United states and to the red soil profiles reported from Palestine, Asia Minor and Central Greece, where the climate is like that in Madras, particularly in the low humidity and rainless summers.

These morphological studies at Coimbatore have served to classify the black and red soils of Deccan on the basis of Sigmond's classification at the International Congress of Soil Science in 1939. According to this scheme of classification both red and black soils are soils of mixed origin or organic mineral soils. The black soils belong to the sub-group "Humic siallites", Soil order—"Calcium soils" and main type—"Black soil". The red soils, on the other hand, come under the sub-group "Ferric siallites" soil order—"Red Earth" and main type "Red soil."

The second part of these fundamental investigation was on the dynamics of the soils and was designed to throw further light on the classification attempted above on morphological considerations. From a chemical study of the soil types, the following general differences were distinguished between the black and red soils.

Black soils had a lower content of free silica and a higher combined silica content than red soils. They had also a higher silica-sesquioxide ratio than the red. The black soils contained a

higher percentage of calcium both as silicate and as carbonate while the red soil had only small amounts of these constituents. Generally black soils contained also a higher percentage of magnesia and soda than red soils. Besides these chemical differences, black soils had also a higher proportion of the finer fractions, a higher water holding capacity and a low distribution of soluble salts in the top three feet.

The common features in both black and red soils were a higher free silica content at the surface and increasing amounts of cambined silica with depth and a constancy of silica-sesquioxide ratio within the profile. These similarities point to a similarity in the extent of the influence of climatic factors like ranfall, temperature and of topography. The formation of the two types of soils often in close proximity may therefore be ascribed to differences in the mineral composition of the parent rock and not external factors.

As a corollory of this conclusion, the mineralogical composition of the soils as well as their parent rocks below, was investigated The soils were separated into various fractions with different specific gravities as below.

(1)	More than 2·96 Sq. gravity ..	Musoovites, Blotites iron minerals.
(2)	Between 2·70 —2·96	Talc, Plagioclase, Mica.
(3)	,, 2·50—2·70	Quartz, Felspar.
(4)	Below 2·50	Clay Minerals.

The colour, crystalline form, cleavage, birefringence and other characteristic features of these minerals were studied in detail. Similarly the underlying rocks beneath these soil types were powdered and divided into fractions. An analysis for chemical composition was also carried out on these several groups obtained from the soils and the parent rocks.

The mineralogical examination of the fine sand fractions of black and red soils combined with the results of fusion analysis of different mineral fractions showed that there are some important characteristics for each type of soil regarding the mineralogical composition. When the three mineral groups and their amounts were studied, they showed differences in nature of the mineral contents between the black and red soils. The black soil contained a higher percentage of the first group (iron group) than the red soils, but the variety of minerals identified is wider in the red soil. The most important difference is that the black soil heavy fractions contain minerals of the amphiboles and pyroxine group like hornblende and augite unlike red soil which contains ilmenite, bhottie, epidote, garnet, and muscovite. On an examination of the minerological content of rocks it is found that the heavy fraction of hornblende bearing rocks contain amphiboles and pyroxines like sandy fractions of black soils while the micaceous and red granites do not.

When the next group of fractions, i.e., between 2:7 and 2·96 specific gravity was studied it was found that mica was completely

absent in black soils while it was present in the red soils. In the next group, namely, quartz group, black soil sand was characterised by plagioclase felspar while red soils have microcline or orthoclase.

It can thus be concluded on the basis of the above facts and mineralogical examination of fine sand in black and red soils that these soils have been developed from rocks of different mineralogical composition. Rocks similar in appearance may really be different in mineralogical composition. The black soils appear to be derived from rocks containing a high percentage of amphiboles and pyroxenes characterised by the presence of large amounts of hornblende and plageoclase. Red soils on the other hand are formed from rocks containing mica and orthoclase felspars.

The next phase of study was the analysis of the clay minerals of the two soils by separation of the colloidal portion in sufficiently large quantities by suitable extraction and sedimentation over different periods of time. In the case of black soil colloids digestion with concentrated hydrochloric acid was sufficient to bring about a complete solution of all the bases but in red soils digestion with concentrated sulphuric acid was found necessary. This was due to the fact that there were two forms of silicates, those completely decomposable by boiling in hydrochloric acid and those that are resistant to this treatment. These two fractions are generally termed as silicate A and silicate B. In red soils this silicate B fraction was present while in black soils it was absent. Further the silica/sesqui oxide ratio in black soil colloids was about three and of the red soil colloid about two. The clay mineral in the black soil colloid is montmorillanite, while it is kaolinite in red soil colloids.

As a sideline of this investigation on the Madras-Deccan soils, some work was also done on the red and black soils of Coimbatore district, that are found in close proximity to each other in the Udumalpet taluk. Samples of both types of soils from this area were separated into fine sand and clay fractions and studied in detail. It was then found that calcium exists mostly in the form of calcium carbonate, with very little of calcium silicate whereas the red soil sand contained no calcium or magnesium in the top layers but only some carbonates in the lower layers. The red soil sand contained more bases than the black soil sand, probably due to the irrigation which is practised in the red soils of this tract. In both red and black soils the lower layers contained more soda and potash.

Microscopic examination revealed more hornblende and less leucoxenes in the black soil sand while red soil sand contained only stray bits of hornblende but more of leucoxenes. A study of the clay fractions showed that black soil colloids were presumably akin to calcium zeolites, while in red soils kaolin was indicated as the clay fraction mineral. In Gobichettipalayam the red soils had their origin from calcium amphibolite indicating that rocks con-

taining calcium silicate in the absence of sodium decompose into red soil. It was also noted during these investigations that the silica/sesqui-oxide ratio which is characteristic of black and red soils is dependent on the pH during the process of soil formation.

The final conclusion from all these studies may be stated as that black soils arise from rocks richer in lime and soda lime minerals, while red soils are formed from rocks rich in alkali **felspars.**

PERMANENT MANURIAL PLOTS, COIMBATORE.

Following the model of the classical permanent manurial fields in Rothamsted a simple set of permanent manurial plots was laid at Coimbatore in the year 1907, when the Central Farm was started. The objective of these plots was to follow the effect during the years, of a regular application of fertilisers on different crops raised on the Coimbatore type of soil. The fertilisers chosen for trial were ammonium sulphate for nitrogen, superphosphate for phosphorus and potassium sulphate for potash. Each of these three fertilisers was applied individually and in combination with others and cattle manure was also included as an organic manure. Another plot which received cattle manure in the first year of experiment and never received any later on was to see the residual effects of cattle manure application. A plot that received no manure of any kind served as the control plot. To accentuate the differential effects of the fertilisers and of cattle manure intensive cropping has been adopted in these plots, with sometimes even three crops in a single year. The crops grown have been mostly cereals: sorghum, ragi, *paniraragu*, *samai* and wheat, though cotton has also been raised in a few years.

Nearly half a century of this kind of continuous cropping has now given very valuable data on the effect of different fertilisers on different crops. Further as each crop has been also analysed chemically along with an analysis of the soil once every year it is possible to work out a balance sheet for the plant nutrients and indicate the manurial requirements of different crops as well.

Perhaps the most important result of these manurial experiments is that the supply of nitrogen and phosphoric acid is the most essential for all the crops tried so far. Another conclusion is that cattle manure is quite as good as and often slightly superior to a complete artificial fertiliser. It has also been noted that as a result of continuous application of artificials, the clay fraction is slowly getting altered, the effect of potassium sulphate being particularly noticeable in this direction.

The main effects observed from the continuous cropping on soil manured with cattle manure and artificial supplying N, P and K singly and in combination are as below: (*a*) The treatment effects fall into two main groups, phosphates and non-phosphates, (*b*) cattle manure has been equal to and sometimes even slightly

superior to N+P+K and to N+P, (*c*) nitrogen applications alone are not sufficient to improve grain yield, (*d*) nitrogen plus phosphate (N+P) is a better combination than phosphate and potash (P+K), (*e*) K by itself is ineffective in improving yields and potassic fertilisers are perhaps not really essential for the cereal crops that have been studied so far.

Analytical and advisory work in the Agricultural Chemistry Section.—One of the major items of work in the Agricultural Chemistry section of the Department of Agriculture is to analyse various samples of soils, manures and feeding stuffs that are received from agriculturists and give them the necessary advice on the queries raised by them. These samples amount to nearly 1,500 per year from the various districts, taluks and villages and the advice asked for is mostly on the suitability of particular soils for growing specific crops, the need or otherwise of applying fertilisers to correct any deficiency of plant food elements, advice regarding the alkaline or acidic nature of the soils and how best to correct it. A large number of water samples also are received for analysis and advice regarding the suitability of wells for growing particular types of crops. In addition to these, the analysis of manures both organic and inorganic is another important item in the analytical and advisory work of the Chemistry section.

Anti-erosion measures advocated by the Agricultural Department, Madras, up to 1943.

District.	*Taluk.*	*Bunding.*	*Scooping.*	*Field weirs.*	*Gully plugging.*	*Contour ploughing.*	*Planting.*	*Remarks.*
60 Visakhapatnam.	Patapatnam and Golukonda.	17 acres ..	..	..	..	..	..	Propaganda done on terracing, bunding and masonry dams.
West Godavari.	..	Bunding recommended in several taluks.	..	..	..	..	Horsegram grown on slopy contours. Trees and nanal grass planted.	
Krishna ..	Nandigama.	..	Basin Lister-worked.	..	..	..	..	
Guntur ..	..	504 acres bunded with bund former and 5,000 acres with *dantulu*.	..	Fourteen weirs constructed in nine villages.	20 acres reclaimed by gully plugging.	..	Contour sowing with *Punasa* Sorghum on 2,013 acres.	
Nellore ..	Kavali, Rapur, Kandukur and Atmakur.	Bunding was demonstrated in Kandukur, Rapur, Atmakur, 5 to 20 per cent increase in yields recorded.	..	5 acres in one village.	25 acres improved by gully plugging.	..	Hedge planting in sandy coastal areas with palmyra, cashew and casuarina against sand drift in twelve villages.	Rs. 500 given as *takkavi* loans for improvements.

Anti-erosion measures advocated by the Agricultural Department, Madras, up to 1943—cont.

District.	*Taluk.*	*Bunding.*	*Scooping.*	*Field weirs.*	*Gully plugging.*	*Contour ploughing.*	*Planting.*	*Remarks.*
Bellary ..	Bellary, Adoni and Rayadrug.	3,200 acres.	..	..	..	..	*Prosopis Juliflora* planted for 150 feet length as hedge plant in Adoni: 500 seedlings of Pungam and Tamarind at Rayadrug.	
Anantapur ..	..	840 acres with bund former.	..	320 acres big bunds with field weirs.	250 acres gully plugging.	100 acres terracing.	150 acres hedge planting.	Famine labour utilized for putting up bunds, 35 loans recommended.
Cuddapah ..	Cuddapah, Proddatur and Pulivendla.	2,798,000 acres bunded.	..	Seven big bunds for 1,800 yards in Jammalamadugu.	..	..	Aloes and other hedge plants planted for 1,500 yards in Jammalamadugu.	Local advisory committees formed to popularize bunding; bund formers given as prizes.
Kurnool ..	Allagadda and Cumbum.	—	One ryot used Basin Lister.	..	Twenty ryots did gully plugging.	..	Strip cropping practised by one ryot in Cumbum.	
Chingleput ..	—	60 acres bunded.	..	..	..	..	Grasses and shrubs planted as check against erosion.	

Chittoor ..	..	500 acres by Department. 500 acres by ryots.	..	—	—	..	..	
North Arcot ..	..	86 acres bunded gave seven per cent increase in yield over unbunded controls.	—	—	..	..	..	
South Arcot ..	..	4,000 acres bunded by ryots themselves with 5-10 per cent increases in various crops.	..	..	..	..	..	
Tiruchirappalli.	Perambalur.	Bunding done.	..	Weirs put up.	..	..	10,000 stumps of *Rudra* and *Vadanarayanan* were planted.	
Madurai ..	Periakulam.	100 acres bunded with 15-20 per cent increase in yield.	..	Fourteen field weirs put up.	..	..	5,000 casuarina seedlings distributed for planting 20 acres sown with Pillipesara.	Soil erosion is serious in blacksoil areas in this district.

Anti-erosion measures advocated by the Agricultural Department, Madras, up to 1943—cont.

District.	*Taluks.*	*Bunding.*	*Scooping.*	*Field weirs.*	*Gully plugging.*	*Contour ploughing.*	*Planting.*	*Remarks.*
Madurai—*cont.*	Tirumangalam.	100 acres—5–6 per cent increase in yield.	..	—	..	..	..	A number of streams in Velur centre was diverted by suitable dams and this has helped to control much of the erosion in black soil areas.
	Nilakottai ..	16 acres—5–10 per cent increase Irungu cholam.	..	..	..	..	..	
	Palani ..	300 acres—10–15 per cent increase in yield.	..	..	..	..	..	
Ramanathapuram.	Srivilliputhur and Aruppukottai.	6,000 acres bunded.	..		..	..	..	Eastern taluks are flat—with not much of erosion.
Tirunelveli ..	Sankarankoil, Koilpatti, Tenkasi and Srivaikuntam.	A total area of 1,400 acres was bunded and in all cases increased crop yields varying from 15–20 per cent were recorded.	—	..	..	..	..	Erosion control is needed only in black soil areas.

Salem	..	..	Local practice of putting bunds with granite blocks, on steep lands was encouraged. 500 acres bunded with bund former.	..	..	..	1,000 acres contour ploughed.	Hedge planting with *Cassia siamea* was advocated. 200 acres planted with hedge plants.	1,000 acres terraced.
Coimbatore	..	..	1,700 acres bunded.	..	..	..	..	..	
Nilgiris	..	..	..	..	..	..	..	54,660 blue gum seedlings distributed free by the Forest Department for planting waste areas. 881 acres contour planted.	300 acres terraced. New land was leased, for grow more food cultivation only on condition of adopting contour planting on such lands. Land of more than one in four slopes not assigned for cropping.
Malabar	..	..	Over 10,000 acres were terraced: existing bunds were repaired and new bunds were put up.	..	..	Gully plugging was done in 300 places.	2,500 acres contour ploughed.	3,000 acres contour planted and hedges planted.	These two districts being hilly, erosion control is highly necessary especially when more areas are cleared for extending food production.

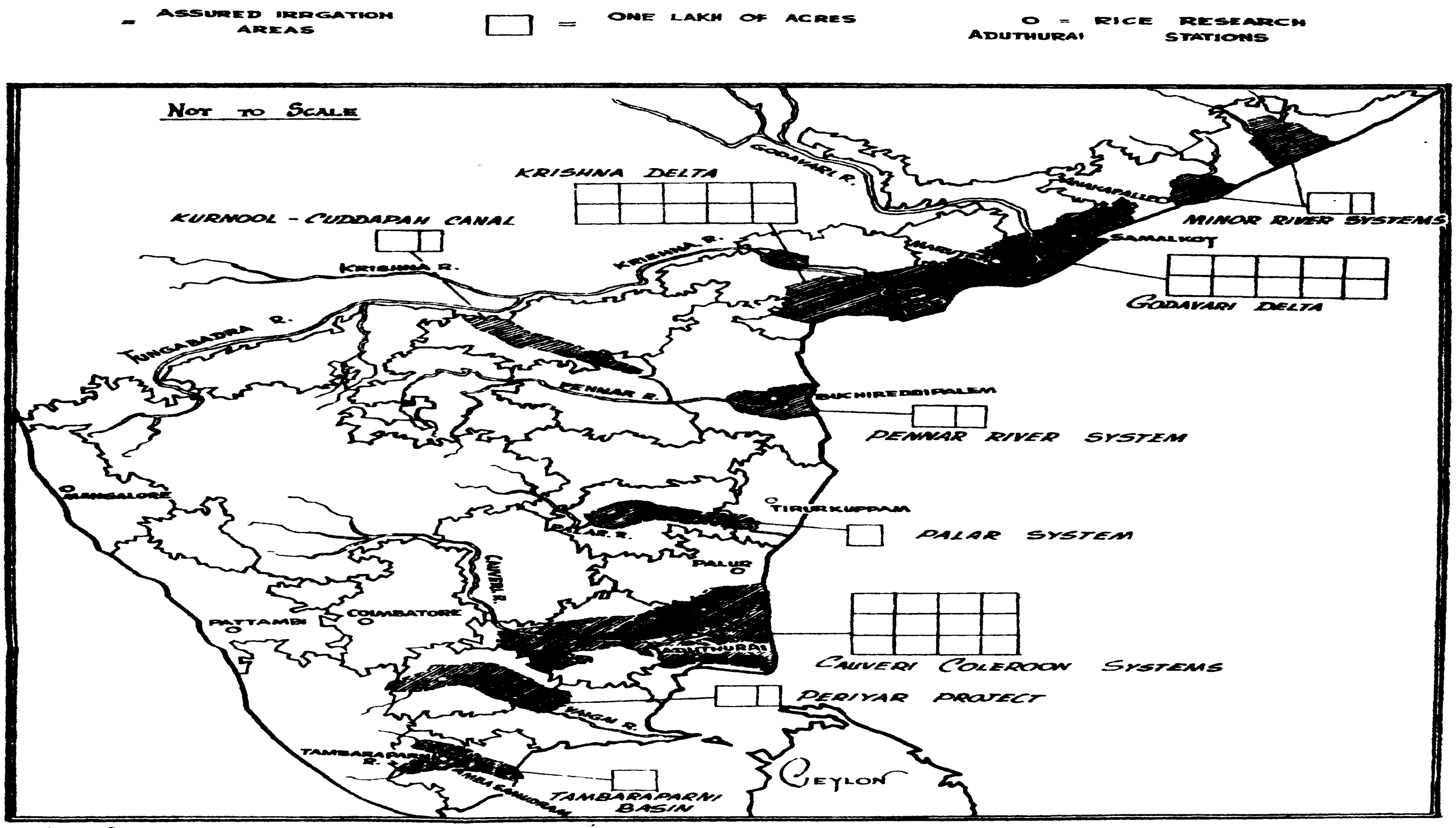
Anti-erosion measures advocated by the Agricultural Department, Madras, up to 1943—cont.

Distict.	*Taluk.*	*Bunding.*	*Scooping.*	*Field weirs.*	*Gully plugging.*	*Contour plougging.*	*Planting.*	*Remarks.*
South Kanara.	..	Here too, bunding and terracing are normal practices as otherwise no cultivation would be possible in the two hilly districts of Malabar and South Kanara.	..	..	..	..	Contour planting has to be popularized in place of the existing practice of planting along the slope.	Intensive propaganda is needed to prevent large scale erosion when forest areas are cleared for extending cultivation.

Comparitive values of Green-manure Crops.

	Daincha. (*Sesbania aculeata*).	*Sunnhemp* (*Crotalaria juncea*).	*Pillipesara* (*Phaseolus trilobus*).	*Cowpea* (*Vigna catiang*).
Green material per acre	21,131 lb.	27,790 lb.	22,337 lb.	21,055 lb.
Nitrogen added to soil (lb. per acre)	133 lb.	134 lb.	102 lb.	74 lb.
Moisture	60 per cent	70 per cent	80 per cent	80 per cent.
Decomposability	Slow	Moderate	Very rapid	Rapid.
Soil nitrogen due to continued application	0·141 per cent	0·109 per cent	0·109 per cent	0·101 per cent.
Soil nitrogen—No manure	0·079 per cent	0·079 per cent	0·079 per cent	0·079 per cent.
Bacterial population with green manure	4·5 million	4·0 million	6·3 million	4·3 million.
Bacterial population—No manure	3·6 million	3·6 million	3·6 million	3·6 million.
Yields: (of Paddy) Grain lb./acre	3,626	3,467	3,626	3,327
Percentage on—No manure (= 100)	207 per cent	198 per cent	207 per cent	190 per cent.
Straw per acre	7,311 lb.	6,554 lb.	6,415 lb.	5,299 lb.
Percentage on—No manure (= 100)	417 per cent	374 per cent	366 per cent	302 per cent.
No manure—Grain	1,753 lb.	1,753 lb.	1,753 lb.	1,753 lb.
Straw	1,753 lb.	1,753 lb.	1,753 lb.	1,753 lb.
Remarks.—	Hardy plant, tolerates drought and also water logging. Grows well even under adverse conditions and gives good yields. Leaves a good residual effect on soil.	Cannot stand water logging; good for fodder also.	Rather slow in growth, serves as fodder also, can be cut and fed to cattle once or twice before ploughing it in.	Grows thick, but needs good drainage.

MAIN IRRIGATION SYSTEMS OF MADRAS



Reg No. 55 '52-750

Helio. P. Z. P., C. S. O., Madras.

CHAPTER 17.

IRRIGATION.

Systems of irrigation—Productive and protective schemes—Need for irrigation research—Suitable soils, crops, practices and water requirements—The Irrigation Development Board, Early experiments, duty of water—Experiments on ryots' lands and at Agricultural Research Stations—Irrigation of black soil, special features—The Agricultural Research Station, Siruguppa and the fundamental and agronomic investigations on irrigation—Results achieved—Block systems of irrigation under the Tungabhadra Project—The Bhagavadi Demonstration Farm.

Agricultural prosperity is always associated with water, the most important limiting factor for crop production. The natural source of supply for all vegetation in the world is of course rainfall, but wherever this is scanty, man's ingenuity has enabled him to secure an artificial supply of water for raising his crops. This artificial application of water to lands, whenever the rainfall is not sufficient to meet the full requirements of crops, is known as irrigation.

Systems of irrigation.—Methods of irrigation have assumed different shapes in human hands, such as dams, barrages, anicuts, tanks, spring channels and wells. Dams are constructed across valleys and rivers to impound the water which runs to waste in certain seasons of the year which it is either not wanted or cannot be completely utilized. Such storage enables the regulation of water-supply at a later date when the crops need water. Barrages and anicuts are constructed across perennial rivers to divert the water flow into canals which feed tanks and irrigate fields. Tanks are designed to store rain-water collected in the catchment area or canal supply to be used later for irrigating crops. Spring channels and wells are dug to tap underground water for irrigation. These systems of irrigation which have helped man to fight against nature's caprices and increase his crop yields, depend ultimately upon rainfall.

Productive irrigation.—The development of irrigation agriculture is limited by the water-supply that is available and the cost of construction of irrigation projects. It is a matter for common knowledge that the cost of an average project runs into crores of rupees and the agency which invests the amount naturally examines and sees before investment whether the capital so invested can be recouped in course of time. It has generally been accepted that any irrigation project, in order to be productive, must be capable of yielding a three per cent interest on the capital outlay. In sanctioning new irrigation projects, therefore, one of the prime

aspects examined is this financial potential productive capacity of the project.

Protective irrigation.—However, there are certain areas where the idea of a scheme being productive, cannot be the sole consideration in launching a project. In the Ceded districts, for example, the rainfall has always been uncertain and insufficient and famines are of frequent occurrence. In such areas, an irrigation project, though unproductive in nature, has to be launched as a protective measure, for averting famines, by providing water in years of bad rainfall to save the crops from failure. This system of irrigation is called a protective scheme of irrigation.

Irrigation schemes are thus productive or protective. On humanitarian considerations, protective schemes are likely to get emphasis but any long range policy should combine production with protection. Almost all the irrigation projects in Madras State are of the productive type. The only big project in which the protective aspect was considered first is the Thungabhadra Project and even this is expected to become eventually a productive scheme, when the results of research are applied in an intelligent fashion. The various irrigation projects in our State, the ayacuts they command and the returns they yield on the original investment, are furnished in the following tabular statement.

Name of the system (productive).	Area in acres.	Percentage return on capital outlay.
1 Godavari	971,964	22·22
2 Krishna	895,228	18·72
3 Cauvery	270,219	14·69
4 Pennar	117,199	8·88
5 Periyar	19,471	5·76
6 Lower Coleroon	84,892	11·84
7 Other systems	568,815	3·10
	2,927,788	9·08
		PER CENT.
Unproductive work	262,989	1·30
Total ..	3,190,777	

Area under irrigation.—The areas irrigated in the Madras State during the years 1943–44 and 1948–49 are shown in the following table :—

	1943–44 ACS.	1948–49 ACS.
1 Irrigation by Government canals from various projects	4,116,904	4,582,899
2 Irrigation by private channels ..	128,986	156,879
3 Irrigation by tanks	3,432,323	2,044,529

	1943–44. ACS.	1948–49. ACS.
4 Wells having independent ayacuts ..	1,543,936	1,784,166
5 Wells supplementing recognized sources of irrigation	207,902	297,836
6 Other sources, i.e., spring channels, etc.	303,457	335,948
Total ..	9,733,508	9,854,212

It will thus be seen that the major irrigation projects from rivers cover nearly 40 per cent of the total area while the tanks cover only 30 per cent. Nearly seventy per cent of the total area under irrigated crops get the supply of water by gravitational flow, while about twenty-five per cent of the area under wells has to depend on lift irrigation through manual, bullock or mechanical power.

Need for irrigation research.—Maximum utilization and quick returns are the prime factors in any large-scale enterprise and irrigation projects are no exception to this rule. Before an irrigation project is launched, therefore, the question must be examined from all aspects of soil, crops, and their water requirements, agricultural practices, etc.

Soils.—The soils under various irrigation systems in Madras State are varied. The alluviums of the deltas, the typical garden lands of the Central Districts, the red soils of the orchards, the laterite formations on the West Coast, the sandy strips along the coast line and the heavy, deep black soils of the Ceded districts are some of the soil types which carry some crop or other, depending on the water supply. These different kinds of soils cannot be expected to react all in the same manner to irrigation.

Crops.—Secondly, a wide variety of crops is also raised under irrigation. The crop that immediately strikes the mind when one thinks of an irrigation project is rice. This is the crop that is grown along with betel vine, bananas and turmeric in wet lands whenever copious irrigation water is available. These crops are cultivated in areas where the system of irrigation is by gravitational flow in channels from rivers and tanks. In garden lands, irrigation is mostly by lift against gravity, from wells and the crops raised are cotton, millets, pulses, wheat and vegetables, although sugarcane, banana and rice may also be raised occasionally in small areas. Orchards get irrigation either from canals or from wells.

Practices.—To meet this wide variety of soils and crops, different irrigation practices have been evolved as suited to certain tracts. For example in the deltas, irrigation of wet lands is always by gravitational flow from the channels and the operation does not require much labour. In Chittoor, North Arcot, Salem, Coimbatore and the districts of the south, irrigation is mainly from tanks and wells. While irrigation from tanks is more or less similar to that from rivers, irrigation from wells presents a different problem,

depending chiefly on the depth of the water table. Various devices like the picottah, mhote and other mechanical contrivances are used. For the garden-land ryot of these districts irrigation charges constitute a substantial portion of the cost of cultivation and that is the reason why the cultivation is limited in area when irrigation has to depend on wells. Again on the sea coast strips, as in Bapatla where the water table is very high and where the soil is sandy and does not permit channels to be formed, irrigation is done by splashing from pots. In such localities it is needless to point out that the holdings are small and the crops that can be raised are also limited in number.

Water requirements of crops.—There is again the other problem that different crops require different amounts of water, depending on their duration, their physiological requirements, rainfall and the conditons under which they are grown. With the same amount of water, therefore, different areas of different crops can be raised and it is essential to know how best to utilise the water for bringing the largest area to maturity. It is this idea that is the basis of what is known as 'duty of water' for different crops. The "duty of water" is defined as the area of a particular crop that can be successfully raised to maturity, with a flow of one "*cusec*" (one cubic foot per second) of water during its growth, including rainfall. For wet crops like rice, the duty will be low, for dry-irrigated crops the duty will be high, whereas for crops like sugarcane, bananas, etc., the duty will be mid-way in between these two extremes. The duty of water has been worked out for different crops in different localities and these results are made use of to determine the ayacuts under irrigation projects.

It will be seen therefore that with different soil types, different crops, different irrigation practices and varying water requirements, irrigation agriculture is very much more difficult and intensive than dry land agriculture and there is need for definite information on the various aspects that are involved.

The Irrigation Development Board.—That irrigation agriculture needs research in various directions has been recognised for quite a long time. As early as 1926 the Royal Commission on Agriculture, drew attention to the lack of irrigation research in this State and finding that the water requirements of crops are studied on empirical lines by Irrigation Engineers, strongly recommended the organisation of irrigation research bringing the Agricultural and Irrigation experts into close co-operation. Again Mr. Priestly, Special Officer of the Upper Bhavani Project, expressed his inability to give any definite opinion on the project, for the reason that he had no information on the nature of the soil, the crops that were suitable and the practices to be adopted. In 1942 the Government seriously considered a proposal for starting a Central Institute for Irrigation Research, but later on dropped the idea since the results obtained would be under

artificial conditions and might not be applicable to all the areas. They then recommended that research experiments should be conducted in some of the existing Agricultural Research Stations in collaboration with the Public Works Department. Meanwhile, the Irrigation Development Board was constituted in 1930, to co-ordinate the activities of all the departments and solve problems connected with the existing irrigation systems and investigation of new projects. The members of the Board were the Commissioner of Land Revenue and Settlement, the Chief Engineer for Irrigation and the Director of Agriculture. One of the main items of work of this Board was a periodical review of irrigation experiments carried out jointly on ryots' lands and in the Agricultural Research Stations by the Chief Engineer and the Director of Agriculture.

Duty of water—Experiments on ryots' lands.—Some of the first experiments on duty of water were conducted in connexion with the Lower Bhavani Project in ryots' fields in two places Perundurai and Modachur in Coimbatore district. The crops tried were cotton, bajra and groundnut. The object of the experiment was to find the amount of water required and the frequency of irrigation for each crop. The experiments at Modachur and Perundurai were under well irrigation with arrangements to measure water led on to the fields by first storing it in a tub of known dimensions. It was felt that this technique could not be compared to the conditions that would prevail later on under the Lower Bhavani Project with flow irrigation. The experiments were then continued during the years 1933–36 in Kugalur and Chinnasamudram where water was available by flow from the channel. At these centres the water was measured by specially constructed V—notches, making it possible to make very accurate calculations under Project conditions. Chinnasamudram is in the first crop zone and Kugalur in the second crop zone of the project area. The results showed that water consumed by the chief commercial crops, namely groundnut in the first crop area and cotton in the second crop area was slightly greater than the project provisions while the requirements for food and fodder crops were lower. It seemed likely therefore, that when food and commercial crops were grown in rotation, the total quantity of water required by the area as a whole would be within the project allowance. At the same time it was seen that Cambodia Cotton gave a more profitable return than cereal crops.

Further the existing Bhavani channels irrigating rice, work at the low duty of 30 acres per *cusec*. To convince the ryots that a higher duty of water was quite possible, experiments were conducted under one sluice in Tadepalli channel from 1930 to 1934. The final conclusion was that the sluices could be remodelled for a duty of 40 and with a slightly lower figure during the transplanting period.

Experiments at Agricultural Research Stations.—Similar experiments were conducted at different stations from 1938 onwards and the results are furnished in the table below :—

Serial number and name of the station.	Crop.	Duty of water.	Remarks.
1 Maruteru ..	Sugarcane	107	
	Bananas	136	
	Rice (first crop)	81	June-December.
	Rice (second crop) ..	54	February-May.
2 Aduthurai ..	Kuruvai rice	68	First crop.
	Thaladi "	80	Second crop.
	Samba "	76	Single crop wet lands.
3 Pattukottai.	Kuruvai rice	37	
	Thaladi "	67	
	Samba "	57	
4 Central Farm, Coimbatore.	Single-crop rice	51	Average of four years.
	Ragi	130	May-September.
	Sorghum	120	March-June.
	Cotton	190	6 months duration.
5 Siruguppa ..	Sorghum	163	June-September.
	Cotton	265	August-March.
	Ragi	126	July-October.
	Wheat	234	November-March.
	Korra	103	June-September.
	Groundnut	156	July-October.
	Rice	60	Single crop.
	Sugarcane	90	

The mean duty of dry irrigated crops worked out to 175, whereas the approximate duty for rice is 60. It will be seen therefore that the duty of dry irrigated crops is roughly three times that for rice. It will also be noticed that cotton has the highest duty and a larger area of this money crop can thus be raised for a definite quantity of water, so that cotton has a great scope under projects such as the Lower Bhavani and Thungabhadra projects.

It is interesting to note that as against an average duty of 60 recorded for rice in all the Agricultural Research Stations, most of the rice crop under the present canals and rivers work to a duty of only 30 or so. It is therefore evident, that by a more economical use of water and by modification of sluices wherever necessary, a larger area can be brought under rice with the existing supply of water itself.

Transmission losses.—To study the transmission losses in canals and field channels, experiments were conducted in ryots, fields in Avadiaparai, Kugalur, Arkankottah and Tadepalli. The observations were made to see how far the allowance for transmission loss in the Lower Bhavani Project, namely, eight cusecs per square feet run of water agreed with the actuals. The results obtained generally indicated that the assumptions made were on the safe side, except in a few cases which could be attributed to the dissimilarity between project channels and the experimental channels.

Transpiration losses.—Rice being the most important crop under any irrigation project, the transpiration losses of this crop were studied in Maruteru and Aduthurai. Losses by evaporation and seepage from the soil were also recorded. It was found at Maruteru that an average loss of 0·02 inches per day, per acre, occurred due to transpiration in the main crop and that the corresponding figure in Aduthurai varied from 0·01 to 0·05 inches. Evaporation losses contributed another 0·02 to 0·03 inches per day, while the seepage loss in Aduthurai was found to be about 0·02 to 0·03 inches per day. All told, the total loss due to transpiration by the crop, evaporation from the surface and seepage from the soil can thus be put down as 1/10 inch per day per acre in the deltaic areas.

The object of these studies was to get at the minimum requirements of water for the maximum yield of crop. Simultaneously with the above experiments fundamental research on some aspects of irrigation in relation to crops and soils was also conducted in some of the stations such as Hagari, Coimbatore and Siruguppa.

The water relationship of cotton.—At Hagari the experiment consisted in a study of the water relationship of the cotton plant, to determine the variations in the rates of transpiration of some representative Madras Cottons belonging to the species *G. hirsutum*, *G. arboreum* and *G. herbaceum*. Later, the scope of the study was extended to the determination of the relation between the transpiration rates and various plant characters like seed weight, lint weight, ginning percentage, lint length, maturity percentage–all characters of economical importance in the selection of the most suitable types.

These varieties of cotton were grown under controlled conditions with known percentage of moisture levels in the soil. The results indicated that in all the varieties studied an increase in the moisture level tended towards a better developed root-system with a longer tap root and a larger number of laterals.

A higher moisture level also contributed to better growth above the soil, the plants growing taller with an increase in the number of internodes, more branches, larger and more numerous leaves. This increase in growth also resulted in an increase in the number of flowers and bolls. While an increase of moisture supply thus tended to increase the flowers and bolls, shedding of bolls and flowers was also increased, differentially in the three varieties. This, to a certain extent, reduced the final yield. For example at 15 per cent moisture level H 1 Cotton (*G. herbaceum*) produced more flowers than Karunganni (*G. arboreum*). But in H 1 Cotton, the shedding was 80 per cent while it was only 54 per cent in Karunganni. It would thus appear that Karunganni is a more drought resistant type than H 1 and as judged by the quantity of water required to produce a unit weight of kapas or seed cotton, Karunganni is the more economical type.

At the Cotton Breeding Station, Coimbatore, another problem studied was how best to irrigate Cambodia cotton under the conditions peculiar to the tract, so as to get an increased outturn with the minimum water-supply, with a view to reduce the cost of cultivation. The quality of the irrigation water was not good as the total salt content was high and it was feared that too many irrigations, while they may not be necessary for the crop, might spoil the soil condition. Experiments were conducted with Cambodia cotton strains Co. 2 and 1267.

The results revealed that the 15th, 18th and 21st weeks after sowing were the critical periods in the growth of the crop and during the period of December-January, two irrigations given at four-week intervals were the most profitable. Irrigations given every week were both unnecessary and wasteful. Some pot culture experiments carried out as an adjunct to these field studies confirmed the critical periods of cotton growth. It was generally found that a moisture level of 30 per cent right through the life-time of the crop gave the best results in cotton.

Irrigation of black soils.—The problem of irrigating black soils assumed importance with the advent of Thungabhadra Project. After a soil survey of the Project area (reported under soils and soil studies), the Government Agricultural Chemist, while recommending the inauguration of the project, had suggested the opening of a Research station. On this station problems relating to irrigation were to be studied by experiments laid out on the field, so that confirmation may be obtained of the results of laboratory examination on soil samples, drawn from the Project area.

Agricultural Research Station, Siruguppa.—It was for this purpose that the Agricultural Research Station, Siruguppa, was started with about 92 acres of black soil with a typical soil profile representing such soil as constituted the major portion of the project area. Water for the conduct of the experiments from the Tungabhadra was provided by pumping the water from Tungabhadra channel in Siruguppa. A good deal of research work was done on the station since 1937, including a fundamental study of the physico-chemical reactions of light and heavy irrigations on the deep and shallow black soils, on agronomic investigation to determine the suitable crops and season, the best rotation and soil management and crop breeding to evolve Cambodia strains suitable for irrigation in black soils in the late (*hingari*) season and to find out a variety of late sorghum (*hingari jonna*) suitable for irrigation in black soils.

Fundamental research—Light irrigation on deep black soils.—Experiments were started in 1937 to study the movement of water soluble salts in deep black soils with light irrigation of varying magnitudes, namely, (1) No irrigation, (2) Irrigation as and when the crops require, (3) Irrigation of two inches in 15 days, (4) Irrigation of two inches once in 30 days, (5) Irrigation of three inches

once in 30 days. The crops grown were sorghum and cotton in the *hingari* season. No ploughing or manuring of the field was done, lest it disturb the physical and chemical status of the soil. Pre-irrigation samples of soils were taken first and subsequently soil samples were taken regularly every year in summer after the harvest of the crop grown and analysed for water soluble salt content. The results showed no indication of a rise of salts to the surface of the soil at any time to make the land saline or alkaline as a result of irrigation.

Light irrigation to shallow soils.—In soils of this type it was thought that since *Garusu* is more superficial, the salts, if accumulated as a result of irrigation, may rise to the surface in summer. For this study, three rounds of soil samples were taken in each year to determine the salt content of the soil profiles with or without gypsum. The soils under study were manured and irrigated once a fortnight. The first round of samples was taken after manuring and before sowing the crop, the second round after the harvest of the crop and the third round during the summer. The soil profiles were divided into three zones, namely, (*a*) first layer which is all composed of soil, (*b*) second layer composed of a mixture of soil and '*Garusu*' and (*c*) third layer composed of '*Garusu*' only. The results showed that in all the three rounds of samples, a greater percentage of salts is seen in the third layer in both the types of soils which indicate that no upward movement of salts takes place in any type of soil.

Heavy irrigation to medium and shallow soils under wet land conditions.—As a contrast to controlled irrigation of the dry crops discussed above, the system of wet land irrigation followed in raising rice and sugarcane is entirely different. The movement of salts was studied in black soils, when cropped with single crop rice, double crop rice and sugarcane in rotation.

The samples were taken at each foot level of soil from the above three systems and analysed for the total water soluble salts. The results revealed that in all the systems of wet land cropping the soluble salts were much less in the post-irrigation samples than in the pre-irrigation ones. The values were higher in all the cases in the lower layers of the soil inspite of adding manure every year once in the case of the single crop rice and twice in the case of double crop rice. An examination of the values with the progress of years showed a steady decline of salt values in all the foot levels.

The above points confirmed once again that there is no upward movement of soluble salts, inspite of adding manure every year.

Soil moisture studies.—These studies were made to observe the penetration and retention of rainfall and irrigation water applied to the black soils under 'dry' and 'irrigated' conditions. Cotton and Sorghum were grown in the experimental plots in alternate years. Soil samples were taken from cotton, sorghum and fallow plots under the three irrigational treatments, namely,

no irrigation, two acre-inches once in 30 days and ryots' method (irrigation given as and when the crop requires).

The data collected showed—

(1) that the percolation of rain water to lower layers is found to be slow in the case of dry plots due to the heavy nature of the black soil but once the moisture film gets established, the percolation of water to the lower strata gradually improves,

(2) that in the case of irrigated fallow plot the percentage of moisture due to seasonal variation is negligibly small below 12 inches of soil, whereas in the case of plots cropped with sorghum and cotton the depletion of soil moisture is noticed right down to three feet,

(3) loss of moisture in the irrigated plots is confined to top one foot only,

(4) the percentage of loss of moisture in the top layers of soil is found to be higher in the irrigated plots than in the dry plots, and

(5) the plots receiving irrigations show a uniform moisture content in all the layers up to the third foot, whereas in the dry plot the percentage of moisture increases with depth.

Study of green manure decomposition in the black soil.—The decomposition of green manure applied to the black soils under dry and irrigated conditions was studied in this experiment. Cropping was restricted to the *hingari* season only. Green manure was applied at the rate of 10,000 lb. per acre. In the soil samples drawn from the plots treated with the dose of green manure the ratio of carbon to nitrogen was estimated as an indication of the soil fertility. It was observed that the application of green leaf every year tends to improve the carbon-nitrogen ratio and the fertility status of black soil.

Salt tolerance studies.—Pot culture studies were made with sorghum, cotton, wheat, korra and chillies with different concentrations of sodium chloride, ranging from 0·05 to 0·50 per cent. The results showed that only sorghum and wheat were tolerant to higher concentrations of salt up to 0·20 per cent which is also found to be the limit of alkaline tolerance of most crops. It may be mentioned in this connection that the salt content of the top three feet of the black soils at the Agricultural Research Station, Siruguppa, has come down from 0·11 to 0·08 per cent in dry lands and from 0·63 to 0·11 per cent in wet lands by continuous irrigation during the past ten years. It should be noted that these percentages are well within the limits of alkali tolerance of the ordinary crops of the tract.

Study of salt content of Thungabhadra water.—Examinations of water samples collected from Siruguppa channel every month showed that the salt concentration ranged from 9 to 28 per 100,000 parts of water. These values were lowest in the months of July and August when the river is normally in floods and a steady rise

occurred from September to April. The investigations thus showed that even in summer, the concentration of salts is far below the dose that is harmful to crop growth.

Estimation of silt content of Thungabhadra river water.—Water samples drawn at different depths of the river Thungabhadra at the anicuts of Siruguppa, Vallabhapuram and Hosakotta and also from the three channels taking off from them were analysed for silt content and the results indicated no difference between the silt contents of the river and channels taking off from it. It also showed maximum silt content during the floods and minimum in summer.

AGRONOMIC STUDIES.

The main line of these investigations was to determine the kind of crops that could be successfully grown, the depth and frequency of irrigation, the best time of sowing, cultural practices, rotation and soil management and the most suitable crops for the different systems of blocks proposed for the project.

Response of irrigation to the existing dry crops.—The chief aim of the project irrigation was to give protection to the dry crops of the tract. The irrigation trials conducted with dry crops, viz., sorghum, groundnut, ' korra ' and cotton, with and without application of manure, showed that, while the dry crops did not give, with mere irrigation alone, any appreciable higher yields than the normal rainfed crops, most of them showed a good response to irrigation, when heavily manured. The results of these experiments are given below :—

(a) Crop yields as a result of mere irrigation (without manuring).

Crop.	Treatment.	Acre yield in lb.
1 Local	Rainfed	401 grain.
Mungari-Patcha jonna	Irrigated	450 „
2 Local Cotton (H. 1)	Rainfed	399 kapas.
	Irrigated	433 „

(b) Crop yields as a result of both irrigation and manuring.

Crop.	Treatment.	Acre yield in lb.
1 Local Cotton (H. 1)	Manured and irrigated.	1,313 kapas.
Hyderabad American Cotton (H.A. 11).	Manured and irrigated.	1,217 „
2 Local irrigated ' Jonna ' ..	Manured and irrigated.	1,302 grain.
Local ' mungari patcha jonna '.	Do.	1,873 „
3 Local korra	Do.	2,030 „
S.I. 593 ' korra ' (Coimbatore).	Do.	1,832 „

Comparing the yield figures in statement (*a*) with those in statement (*b*) it would be seen that the increase of crop yields is three to six-fold under manured and irrigated conditions.

Effect of early and late sowing of crops.—At present the dry crops of the tract are sown in any part of the season, conditioned by the incidence of rain and nature of soil. With the advent of irrigation, crops can be sown in the proper time, with better yields.

The trials conducted to find out the optimum time of sowing on the important crops of the tract, sorghum, ' korra ' and groundnut, showed evidence of good response, when sown in June while for sowing cotton, the second and third week of August was found to be the best. Late sowings of the above crops adversely affected the yields and especially so in the case of American cottons. This is well exemplified in the ' time of sowing trials ' conducted on four varieties of American cotton, the results of which are given below :—

Varieties.	Kapas yield in lb. per acre. August 1st.	August 15th.	September 1st.	September 15th.	Remarks.
(1) M.A. 11 (Mysore-American)	1,193	1,302	810	215	Cotton crop received normal manuring and irrigation.
(2) Parbhani American ..	988	1,014	614	130	
(3) H.A. (Hyderabad-American).	833	891	347	18	
(4) G-1 X G. 2-5	783	825	462	89	

In all cases, higher yields were obtained in the first two batches of cotton sown in August. Besides the time of sowing, other factors that should be taken into consideration for good crop yields are manuring, irrigation and the choice of varieties.

Study of intensity and frequency of irrigation.—The trials conducted on the station showed that an irrigation of two-acre-inches of water given once a fortnight was the optimum for most of the dry crops. This quantity was therefore fixed as the standard for the dry crops, viz., sorghum, ' korra ', groundnut, cotton, wheat, ragi, chillies, etc., that are proposed to be grown under irrigation under the project.

The crops on the station that were irrigated regularly once in 15 days with varying depths of water gave the following yields :—

Crops.	Depth of water and their duty. 1·50 inches (222 duty).	1·85 inches (180 duty).	2·0 inches (166 duty).
1 Sorghum	938	919	915
2 Groundnut	719	687	670
3 Cotton	397	355	339

The yields of the above crops were not affected when irrigated with less than two acre-inches of water once in 15 days.

Methods of irrigation.—Of the several methods of irrigation tried on this station, the one that proved best was the long narrow bed system, since it admitted the using of the country drill for sowing, cattle power for intercultivation with the local implements and handling of a larger volume of water by a single irrigator. The optimum width and the length of the beds under

the system was 5 to 7 feet and 50 to 100 feet respectively, the length varying, however, with the slope of the land. The amount of water that could be conveniently handled by one irrigator to irrigate the long narrow beds was found to be any quantity between 0·25 to 0·50 cusec.

The cultivators of black soil are cautioned against over-irrigation of dry crops. The application of water should only be to replace or supplement rainfall.

In the system of irrigation proposed to be followed under the project, it is one of the suggestions that permanent blocks as 'mungari' and 'hingari' blocks would be formed and water supplied to these blocks only in one season either in the 'mungari' or 'hingari' for four months in the year. In such a case, in the 'mungari blocks' where cereals and groundnut are to be grown, cereals follow cereals every year or a groundnut crop follows a cereal in alternate years. Rotation experiments were conducted in the '*mungari block*' for three years with the following average crop yields :—

	Grain in lb. per acre.	Grain in lb. per acre.	Remarks.
1 Sorghum after sorghum ..	1,521	3,184	Manuring same for
2 Sorghum after groundnut ..	1,876	3,795	both every year.

The yield of sorghum was found better after a crop of groundnut.

Trial of crop mixtures.—The practice of growing mixtures of different crops is primarily meant to economise land, labour and water and to counteract the effects of excessive soil moisture. In the Siruguppa tract, there is already the practice of mixing a cereal with a pulse crop during the '*mungari*' season in dry lands. To secure the same benefit under irrigated conditions, pulses with cereals, groundnut with redgram, 'korra' with cotton and redgram, 'pillipesara' with sorghum were tried at the station. Of the several mixtures, only groundnut (local bunch) with redgram proved a success with good profits.

Manurial trials.—Manurial trials were conducted with the most important crops, namely, sorghum and cotton and showed that higher yields were obtained with increased doses of manures, indicating the importance of adequate manuring on the irrigated black soils.

Residual effect of manures on the succeeding crops.—In one of the manurial experiments conducted with cotton, the residual effect of the manures applied to the previous cotton crop was studied on the succeeding wheat crop for two seasons. No residual effects were seen on the succeeding wheat crop. It is therefore found necessary that the black soils of the tract, when irrigated require sufficient manuring every year for ensuring good crop yields.

Trial of improved and new varieties of crops suitable for irrigated dry, garden and wet lands.—Improved strains such as Co. 9 Jonna, N. 1 korra, H.A. 11 cotton were found to respond better to irrigation and manuring than the local dry crops. New crops that were grown successfully in the black soils were wheat, maize, onions, chillies, ragi and varieties of vegetables (tomatoes, brinjals, etc.), GEB. 24, AKP. 2 and HS. 19 rice strains were found suitable for the wet lands. Co. 419 sugarcane was found to be the best among the sugarcane varieties tried.

Investigations on the block systems of irrigation under Thungabhadra Project.—Since the policy of the Tungabhadra Project is to benefit a large area of the tract, it was proposed to supply water once a fortnight for a period of four months in the year and align blocks on the basis of '*mungari*' and '*hingari*' cropping. Water for the '*mungari*' blocks will be supplied from the beginning of June to the end of September and for the '*hingari*' blocks from the commencement of October to the end of January. The investigations were commenced from 1942 and the experience gained during the following four years showed that it was possible to raise crops on black soils both in the '*mungari*' and '*hingari*' seasons. The crops found suitable for the '*mungari*' blocks were sorghum, Setaria (korra), ragi, chillies, maize and groundnut and for the '*hingari*' season, cotton, wheat, maize and chillies. In this blocks system, cotton in the '*mungari*' and sorghum in the '*hingari*' season could not be grown successfully. The cultivators of the blocks had to lose one of these two important crops. It was therefore proposed to rotate the cropping by treating the same block as '*mungari*' in one year and '*hingari*' in the following year. The chief difficulty in this method was that a long gap of about eleven months was created by following '*hingari*' after '*mungari*' which keeps the land unnecessarily fallow for a considerable portion of the year and a very short gap of only two months was available by following '*mungari*' after '*hingari*' which does not allow sufficient time for the various items of preparatory cultivation and to keep the land ready for sowing the '*mungari*' crops in June. Thus, on the whole, the three-blocks system investigated for the project was not found to work satisfactorily.

Supply of water to a holding has therefore been recommended for full eight months in which a portion of one's holding would be irrigated in the early season (*mungari*) and another portion in the late season (*hingari*) in such a way that not more than 50 per cent of the holding would be cropped at any one time.

Wetland cropping.—Wetland irrigation under the Thungabhadra river has been in existence for several centuries. Ryots in those areas are therefore conversant with wetland agricultural practices and do not need much guidance when the full project comes into existence as the ryot has to grow dry irrigated crops. All the same, in the Siruguppa farm, there is a wet land block

where in addition to studying the movement of the salts under heavy irrigation, cropping trials have also been carried out. The following conclusions are possible from these trials. It was found that a single crop rice was better than a double crop one, the former giving more consistent results. In the case of sugarcane-rice rotations on account of a fallow between the months of September to June every two years, it was noticed that the yield of both sugarcane and rice was increased. It was also seen that the wet land cropping could be done both on deep and shallow soils and suggested the possibility of utilizing the shallow soils of the area for the cultivation of rice. Another finding of the wet land cropping trials in Siruguppa which has a practical application is that unless water is made available for 12 months, sugarcane will have to fade out of the picture.

Application of results of rescarch to practical case—Bhagawadi Demonstration Farm.—This farm was started in the year 1944 with a view to study the psychology, stamina and intelligence of the villagers and gauge the eagerness with which they would take to dry, irrigated and wet crops. The water for irrigation was supplied by extending the existing Siruguppa channel up to Bhagawadi, free of charge. In the beginning, inspite of the concessions granted, the ryots were not keen on taking water and the development was slow. Many preferred to take water only when the rains failed and when the crops withered from drought. They did not irrigate the crops as frequently as was provided for under the project conditions. The departmental staff gave the ryots technical advice on the growing of irrigated crops, the time of sowing, cultural and manurial operations with a view to bring as much area of the farm under irrigation, besides supplying them improved seeds. After six years of propaganda almost all the area was brought under irrigation. The cultivators have now become irrigation-minded and are fully utilizing the water given to them. Impiooved methods of irrigation, by long linear bed system, have been adopted. Improved strains of sorghum, korra, cotton and redgram were sown and new crops like wheat, groundnut, redgram were cultivated. Judging from the time taken by the ryots of Bhagawadi to develop the farm, it is presumed that the Thungabhadra Project may take ten to twelve years for full development.

CHAPTER 18.

MANURIAL EXPERIMENTS AND RESEARCH.

Review of manurial experiments on different crops—Manures and fertilizers—Green manures—Cattle manure, its storage and preservation—Sheep penning—Methods of manufacture and manurial value of night soil and organic composts—Oil cakes—*Fertilizers*, ammonium sulphate, sodium nitrate, ammonium nitrate, calcium, cyanamide, rock phosphate, superphosphate, potassic manures, lime—*Miscellaneous manures*, sewage and activated sludge, slaughter-house and tannery refuse, salt earth, mill waste, press mud, rice husk—Manuring experiments on crops and results obtained, rice, sugarcane, bananas, garden crops, cereals, groundnut, cotton, and dry land crops—Some general considerations for manuring in Madras State—Chemical composition of different manures—Dosages for different crops.

The importance of manuring for efficient crop production and maintenance of soil fertility has been recognized from the earliest times in all countries. Manurial experiments to assess the needs of the major agricultural crops raised in the various soil-climatic regions of the State have been in progress during the past three decades and more. In the earlier years, i.e., before 1930 most of the experiments were carried out according to the then prevailing technique for field experiments, either in single plots or without suitable number of replications. Thanks to the recent advances in statistical technique, the defect has since been rectified and a considerable amount of valuable information has been accumulated regarding the plant food requirements of many important crops in the State. The experiments which have been done in the past ten or fifteen years show a marked improvement in quality when compared to those carried out in the earlier period. These later trials in general, while proving to be of greater value than the previous ones, have particularly afforded information on the relative merits of the several manures, especially nitrogenous and phosphatic (organic as well as inorganic) in regard to the chief crops of the State.

In this chapter, an attempt has been made to present the results of the various manurial experiments carried out in the State over a period of nearly forty years in a popular form. The experimental work relates to the testing of the manurial value of a number of organic manures and artificial fertilizers, cattle manure, sheep manure, different green manures, composts from different kinds of waste organic refuse, fish guano, poudrette, sewage, ashes, ammonium sulphate, sodium nitrate, calcium cyanamide, phosphates like ammophos, superphosphate, bonemeal and rock phosphate, potassium sulphate, lime, etc. The crops experimented

with were rice, sugarcane, cotton, millets, groundnut, tobacco, coconut, potato, plantains, chillies and pepper.

The general findings from these experiments are that the most successful and economic manures are green manures with or without phosphates in rice lands, oil-cakes and ammonium sulphate for sugarcane, and cattle manure or compost for all garden and dry lands. The use of artificials in conjunction with bulky organic manures has invariably proved very efficient for crops in all the tracts of the State. The behaviour of sodium nitrate and cynamide among nitrogenous artificials has not been quite satisfactory. In many cases, they had bad residual effects on soils, besides being uneconomical. The experiments, for instance, with sodium nitrate on rice have shown that the increase due to this fertiliser follows a downward tendency year after year, while with the other artificials including ammonium sulphate, there are indications of diminishing returns due to their continued use. However, when these, particularly ammonium sulphate, are applied judiciously in combination with organic manures, bulky or concentrated, their performance is far better than when used alone. These results have been confirmed both by laboratory investigations and field trials.

As regards phosphatic fertilisers their behaviour has been rather erratic and they have not proved quite useful for most of our crops with the exception of potato, in spite of the fact that the arable lands of the State are in general deficient in P_2O_5 In combination with nitrogenous manures, super is far more efficacious than bone-meal, but when used alone its action cannot always be depended upon. Under favourable conditions bone-meal may prove a safe and reliable phosphatic manure with good residual effects. Its failure at times is probably due to its being ground not sufficiently fine.

The experience of a number of investigators in different parts of the world lends support to the conclusions from our manurial experiments on various crops in the State. Investigations on the value of organic manures go to show the importance of these manures in improving the quality and reproductive capacity of the seeds apart from increasing the yield and maintaining the fertility of our soils.

The results of the experimental work on manuring can be classified according to the nature of the manures used in relation to different crops.

Organic manures.—(*a*) Bulky manures, e.g., green manures, composts, farmyard manure, green leaves, molasses, etc., and (*b*) concentrated manures, e.g., oil-cakes.

Inorganic fertilizers.—(*a*) Nitrogenous, (*b*) Phosphatic and (*c*) Potassic.

Special attention has been devoted to the study of the performance of organic and inorganic manures supplying the essential plant food elements, N, K and P, when applied individually and

in combination to the various crops with reference to the different soil-climatic zones of the State represented by the Agricultural Stations. Apart from the dosages of manures tried, the effects of some of them with reference to their form or quality, time and method of application have been studied in relation to a few selected crops, particularly rice, sugarcane and potato. Based on the results of these experiments, recommendations have been made regarding the nature and dosages of manures for the major crops grown in the different tracts of Madras State.

For the sake of convenience and easy understanding the results are discussed both according to manures and crops.

MANURES.

(*a*) *Bulky organic manures*—(1) *Green manures.*—Among the bulky organic manures, green manures occupy a unique place, especially in rice manuring. About 1·25 million acres of rice fields are green manured by growing mainly leguminous green manures *in situ* and about 0·75 million acres are manured with green leaves. Green manuring *in situ* is easy and economical in places where there are irrigation facilities or timely rainfall can be expected. It is estimated that nearly five million acres can be brought under this manure. Taking the average as two tons per acre, the total quantity of green leaves applied to the rice fields works out to four million tons. Experiments conducted by the Agricultural Department in the Research Stations and on ryots' fields show that the average increase in the yield of paddy (rice in husk) is *one pound for every* 1·5 *lb. of leaves* applied and the optimum dosage is about two tons or 4,000 to 5,000 lb. per acre to supply about 30 lb. N. The common green manures grown in the State are sunnhemp, (*C. juncea*), daincha (*Sesbania aculeata*), indigo (*Indigofera*), Pillipesara (*Phaseolus trilobus*) and kolinji (*Tephrosia purpurea*). Enough information has been accumulated on the efficacy of green manuring and it is now a comparatively simple matter to advocate the suitable types of green manures for the different localities.

Of the several green manures, *Pillipesara* (*P. trilobus*) has been found most efficient, particularly in Godavari and Kistna deltas. It has got certain special advantages over the others, viz., (1) it is a valuable succulent fodder, hence the cuttings can be fed to cattle; (2) the aftermath can be puddled in as green manure; (3) it can be sown in the standing crop of rice; (4) it is a crop with plenty of foliage and unlike daincha has little woody tissue; hence there will be no difficulty in incorporating the same in the soil; (5) it decomposes readily in the soil and (6) the plant is not so delicate as sunnhemp and can thrive in heavy clays with one or two waterings during summer, yielding over 20,000 lb. of green matter per acre.

In fertile soils containing over 0.07 per cent of N and over 0.06 per cent of available P_2O_5 and which yield about 3,000 lb grain per acre, the effect of green manure will not be felt appreciably. Its value is, however, most apparent in soils of medium or low fertility. The increase in the average acre yield of rice in Coimbatore Central Farm wet lands from about 2,000 to 4,000 lb. in the course of about 20 years has all been due to the systematic growing of a green manure crop in rotation with rice. In the Hospet area of Bellary district, in spite of the fact that sugarcane is an exhausting crop, the average yield of rice always been 3,000 lb. per acre due to the practice of growing a crop of sunnhemp as green manure between rice and sugarcane, the dose being about 5,000 lb. in most cases. Higher doses have been found beneficial in some poor soils but repeated applications of such heavy doses have been found to depress the yield, unless supplemented perhaps by some phosphatic manures such as bone-meal or super. Increase in yield due to green manure application usually varies from eight to twenty-five per cent depending on the nature of the soil. Organic matter as such when applied to the soil does not confer any lasting benefit on the soil unless it is first converted into humus. Conditions which govern the decomposition of green manure and its conversion into humus have been very exhaustively studied and apart from moisture, what is known as the C : N ratio has been found to be a predominant factor in making the green manure nitrogen available for the crop.

Experiments on the Cotton Breeding Station garden lands at Coimbatore on the cotton crop have shown this. Three manures were under trial, ammonium sulphate, green manure and cattle manure and although nitrification was quicker in ammonium sulphate, the green manure and cattle manure plots had better crop growth. Laboratory experiments proved that due to defective carbon-nitrogen ratio, the nitrogen of the ammonium sulphate was not properly utilised by the crop, being lost by conversion into body proteids by micro-organisms. On the other hand, the nitric nitrogen in the green manured plot, which had a narrower carbon-nitrogen ratio, was utilized and it was established that it is an advantage to put in adequate amounts of green manure in the soil and let the micro-organisms fix the nitrogen from the air, rather than use nitrogenous fertilisers like ammonium sulphate for the cotton crop, under such or similar condition.

The decomposition of green manure in wet land follows a different course from that observed under dry and garden land conditions. A classic investigation extending over several years in the field and the laboratory has thrown much light on the nature and decomposition occurring in swamp paddy soils. The main conclusions were as follows :—

Normal fermentation of green manure in paddy soils leads to the production of relatively large proportions of methane

and smaller amounts of nitrogen together with some carbon-dioxide and hydrogen. This happened under fallow conditions and when a crop was introduced there was a restriction to the formation of methane and hydrogen and the normal evolution of nitrogen. The soil conditions in paddy field being anaerobic in character and making nitrification impossible it was concluded that the nitrogen required by the crop was obtained from ammonia. Incidentally it was noticed that the organised algal films on the surface of the soil utilized the gases in such a manner as to bring about an increased oxygen output and enables maximum oxygen concentration to be produced in the water entering the soil. This increased oxygen production results in efficient root aeration and on this finding the beneficial effect of green manure was to be attributed more to the increased aeration of crop roots than in the nitrogen supplied. In other words, the advantage of green manuring in paddy lands is more physical than chemical.

While this indirect effect of green manures has not been disputed, subsequent work both at Coimbatore and elsewhere (e.g. in Ceylon) has amply demonstrated the direct manurial value of green manures for rice. This work has shown that as a result of incorporating green manure in rice fields, large amounts of ammonia were made available at all stages of the decomposition.

Additional support for this view is derived from the fact, that artificial nitrogenous manures have been found to supplement smaller doses (2,000 to 3,000 lb.) of green manure but not larger ones (8,000 lb.). Physically green manuring induces a more open texture in the soils and aids drainage. The value of green manures is further enhanced by the fact, that they have the power of making slow acting phosphates like bone-meal or mineral phosphates more easily available on account of the acids developed during their fermentation in the soil. Green manuring under irrigated garden land condition has proved beneficial for sugar-cane, cotton and also potato. In garden land, for instance, wild indigo with cattle manure is commonly applied at Anakapalle although cakes can replace either. At Coimbatore green manure increased the yield of Cambodia cotton by 10 to 20 per cent. The utility of this manure for dry land crops is restricted due to inadequate supply of moisture in the soil which is necessary for the speedy decomposition of the green material before the sowing of the main crops in time.

As regards the comparative value of green leaf and green manure, the evidence is inconclusive. At Nandyal, green leaf did not prove always better than green manure and at Coimbatore there was no difference between the two. The best crop to use as green manure varies with the tract. At Palur, *daincha* and wild indigo among green manures and *yerukkam* (*Calatropis gigantea*) among green leaf manures were found the best. At Coimbatore, *daincha* was preferred while at Samalkota, *daincha*, sunnhemp and

teega pasalu (*P. mungo*) had the same value. Cowpea is used at Kasargod and Taliparamba. In Tanjore, *kolinji* is grown widely besides *pillipesara* and sunnhemp. The different green manures differ in their composition. The manurial composition of the important green manures and green leaves is summarized in the statement at the end of this chapter. Recent experiments in this country and elsewhere on leguminous green manure crops have revealed the possibility of increasing their nitrogen and organic matter contents by manuring the crops with phosphates and potash. By resorting to this practice, the direct addition of phosphates or potash to our crops can be dispensed with since these have been applied to the green manure to be ploughed in.

(2) *Cattle manure.*—This is invariably used mostly for garden land crops and to a very limited extent only for rice. The total production of cattle-dung is estimated at 20 million tons, and on a generous estimate 50 per cent of this may be expected to be applied to lands. The balance is either burnt as fuel or wasted through neglect to collect. As a manure for rice, cattle manure has been found slightly but consistently inferior to green leaf both at Aduthurai and Coimbatore. The increase obtained by cattle manure over 'no manure' on rice in a few select areas are as follows :—

	PER CENT.		PER CENT.
Maganallur	25	Coimbatore	13
Aduthurai	18	Pattambi	16
Samalkot	12		

At Manganallur and Aduthurai cattle manure was exclusively used without being supplemented by artificial manures whether nitrogenous or phosphates. At Coimbatore, however, the phosphates viz., ammonium phosphate, and a combination of super and ammonium sulphate increased the yields from cattle manure. At Nandyal, cattle manure and green leaf were found superior to green manure alone. Due to the better value of green leaf and the greater demand for cattle manure for garden lands, the use of cattle manure in paddy lands can be excluded wherever green manures are available.

For sugarcane except at Anakapalle cattle manure has not given very encouraging results. At Samalkota, 10 tons of cattle manure was found to have the same value as 2½ bags of castor cake. In the case of garden and dry crops, cattle manure has been found to be by far the best manure. At Coimbatore, it has in general shown itself equal to the completely manured plot throughout the period of study. Experience at the Central Farm has demonstrated that it is possible to maintain a high standard of yield on garden lands by cattle manure alone. Nine cart-loads per acre applied to cotton at the Cotton Breeding Station, Coimbatore, gave an increase of 18 per cent in yield of *kappas*.

On dry crops, it has been found beneficial wherever it was applied. An increase of 70 to 100 per cent has been obtained

with sorghum and bajra crops at Koilpatti and about 40 per cent with cotton. At Nandyal it gave from 90 to 120 per cent higher yield of sorghum and 60 to 80 per cent of cotton applied every alternate year or annually. Similar but less increases (30 per cent) have been recorded both for cotton and cereals at Hagari. Its beneficial effects could be traced even up to five years after application at Koilpatti and other places.

Among the different systems of preserving cattle manure the loose-box has shown itself superior both for direct and residual effects at Koilpatti and to a less extent at Nandyal, Hagari and Bellary. The same was true on the rice crop at Samalkot.

The application of ammonium sulphate (2 cwts.) and super (1 cwt.) with cattle manure (6 cart-loads) or groundnut cake (250 lb.) per acre increased the yields of the crops, viz., cotton, sorghum, bajra, etc., up to 40 per cent with good residual effects up to the third year after application in all the centres tried.

Cattle manure has proved an excellent manure for potato, a combination with fish manure being the best with increases ranging from four to sevenfold.

On coconuts this manure (100 lb. per tree) has shown the highest increased production of nuts per tree being superior in this respect to the complete mineral manure (N + P + K) which comes next.

Sheep penning.—This form of manuring was found superior to application of cakes or fish guano for '*pyru chodi*' at Anakapalle. At Nandyal, sheep penning doubled the yield of sorghum whether applied annually or in alternate years while with cotton the increases were 65 and 40 per cent respectively. It did not, however, fare well at Hagari, the increase being 9 per cent only. In manurial value it had about the same value as cattle manure at Nandyal and Koilpatti while at Hagari it was inferior for cereals, but superior for cotton.

(3) *Nightsoil and organic composts.*—Due to dearth of cattle manure to meet the entire needs of the arable lands, a number of investigations came to be carried out for the preparation of composts using all kinds of waste organic materials such as municipal rubbish, tannery refuse, slaughter-house wastes, prickly-pear, cotton stalks, weeds and waste straws, things rendered unfit for human consumption, night-soil, etc. Among the various methods of compost making developed so far, namely, the local, Indore and Bangalore processes, the last is widely adopted now in most of the municipalities of this State and elsewhere. It is claimed that the Bangalore process is much simpler and requires considerably less quantity of water than the Indore process. The method of composting nightsoil and town wastes is, in brief, as follows :—

" A layer of refuse about nine to ten inches thick is spread at the bottom of a convenient trench not bigger than

40 feet by 9 feet by 4 feet and over this is added a quantity of nightsoil corresponding to a thickness of three inches. Successive layers of refuse and nightsoil are similarly added till the heap rises to a foot above ground level. Each layer of the nightsoil is immediately covered over with refuse up to nine inches thick. The top layer at the end of each day is covered with a thin layer of earth about ½ to 1 inch thick to prevent fly breeding and to avoid smell nuisance altogether. At the end of four months' decomposition, the manure is ready for application to land and the resulting product is found to be a well decomposed, odourless inocuous manure of high manurial value, superior to farm-yard manure." It is estimated that 1,000 tons of compost manure can be prepared daily by this process for the total population in our State. The compost thus prepared is claimed to be better than cattle manure due to its higher manurial value—vide statement below :—

Manurial values of nightsoil compost and cattle manure.

	N.	P_2O_5	K_2O
	PER CENT.	PER CENT.	PER CENT.
(1) Nightsoil compost (Municipal) ..	1·13	1·08	1·06
(2) Cattle manure (pits)	0·52	0·33	0·99
(3) Cattle manure (Byre)	0·97	0·47	1·70

The trials with mere organic composts, prepared without nightsoil addition according to the local method but involving the use of bone-meal and straw as litter, at Koilpatti Aduthurai and other places show that they are as good as loose box manure. The recent experiments on rice at Pattambi and on ragi in the Central Farm, Coimbatore, have not established the superiority of Bangalore compost over cattle manure when each is applied on bulk basis. Further experiments are in progress at the several agricultural research stations of the State to test the comparative values of Bangalore compost and farmyard manure.

Concentrated organic manures—(1) *Oil-cakes.*—About three lakhs of tons of oil-cakes are produced in Madras and the actual quantity applied to the lands is reckoned at two lakhs of tons, the balance being used largely as cattle feed. Different kinds of oil-cakes, particularly groundnut-cake have been tried on rice to supply 20 to 60 lb. of nitrogen per acre in several agricultural research stations. The results have been quite uniform in all the stations and the increases obtained varied from 15 to 50 per cent over the control. The different cakes are more or less alike in their effects when applied on equal nitrogen basis. In most of the experiments cake has been found to be in no way inferior to ammonium sulphate. Another interesting indication is the differential response when applied to rice grown in different seasons. For instance, at Aduthurai better response is obtained for the first crop (July-October) while the results are in favour

of the second crop at Maruteru (January-April) and Pattambi (October-January). It appears from these trials, that the response is better with short season crops in all the three places. Cakes have also the remarkable power of supplementing super. At Samalkota this increase ranged from 20 per cent on the first crop to 80 per cent on the second, while at Manganallur the same crop benefited to the extent of 70 per cent. At Nandyal, cake plus super was found to be as good as the local combination of green leaf and cattle manure.

Cakes also form the best manure for sugarcane. The best response has been noticed with a combination of cake and ammonium sulphate—nitrogen applied in the ratio of 4 :1 or 3 :2 at the rate of 100 to 150 lb. N. per acre in two doses—one at planting and the other at the earthing up stage. The economic dose of cake-nitrogen for Anakapalle is 100 lb. while at Palur it can be increased to 150 lb.

For dry and garden land crops, groundnut cake in combination with super has been found beneficial at Koilpatti and other places for both cotton and cereals with good residual effects even up to three years.

(2) *Fish guano, fish meal, etc.*—These are important organic manures containing both nitrogen and phosphoric acid in about equal amounts, especially in the West Coast. The crude manure as usually prepared contains also considerable amount of sodium chloride which is considered beneficial to coconut trees.

At Pattambi fish guano has been found very efficient for rice, 400 lb. of it being equal in effect to 4,000 lb. of green leaf. The highest yields were obtained with the combination of 400 lb. fish guano and 2,000 lb. green leaf. Its performance, however, was not uniform in all the places though it had some residual effects. At Samalkot, fish guano increased the yields of rice in some fields only and came next in value to green leaf and super. At Nandyal, it was found worse than green leaf plus cattle manure.

In regard to garden and dry crops, fish guano was inferior to cattle manure for fodder sorghum at Koilpatti. It was found to be an excellent manure for potato, giving increased yields (even) upto 15 cwts. dose, while in combination with cattle manure it proved to be the best manure for the crop. For '*pyru chodi*' at Anakapalle, fish guano had the same value as cakes but was inferior to sheep penning.

ARTIFICIAL MANURES.

Nitrogenous manures—(1) *Ammonium sulphate.*—Among the nitrogenous fertilisers ammonium sulphate is extremely popular and is widely used for rice, sugarcane, cotton and other crops. It is a well established fact that rice in particular responds very well to nitrogen in the form of ammonium sulphate. It has been found to be invariably very good for this crop in all the

regions of the State. The increases obtained in the several cases for 30 lb. N supplied as ammonium sulphate ranged from 25 to 40 per cent. Except in areas with a pronounced nitrogen deficiency as at Manganallur it has no better value over green leaf, nor does it supplement larger doses of green leaves in these tracts. At Samalkota, and to a certain extent at Coimbatore, green leaf alone was found quite as good. In a few places, the continuous application of this manure by itself is reported to have bad after-effects. Further, when ammonium sulphate is applied together with green manures, the response is generally greater than for a mixture of green leaf and cake on the same N basis, the increases being 19 and 15 per cent over the respective controls. Better response is also evident with ammonium sulphate when applied in conjunction with other bulky organic manures like compost and cattle manure. The best time of application of ammonium sulphate for rice is one month after planting in a single dose either alone or with a basal dressing of green leaf or green leaf plus super. This practice has resulted in very good yields in all the places. This fertiliser, like cakes, has practically very little residual effect.

Experiments conducted in research stations show that the application of graded doses of ammonium sulphate (50, 100 and 150 lb.) to rice crops grown under irrigation results in graded increases in yield within limits and up to a point. The increases that could be expected from the different rates of application are as below :—

Increased yields of paddy from different doses of ammonium sulphate.

Am SO_4 dose.		Increase in grain yield.
LB.		LB.
50	..	150
100	..	300
150	..	600

The increases are also stated to be economical. In general, 100 to 150 lb. will be found profitable in all localities. These observations have been confirmed by trials conducted in one acre blocks in several rice growing tracts, viz., West Godavari, Tanjore, North Arcot, Tiruchirappalli, Tirunelveli, etc. In certain districts, viz., Nellore, Chittoor and Guntur, a lower dose of 100 lb. per acre was found to be more profitable. It is advisable to apply ammonium sulphate in conjunction with organic manures such as cattle manure, oil-cakes or green manure to derive maximum benefit.

The effect of this fertiliser on the next important crop sugarcane is equally good. At Anakapalle ammonium sulphate plots gave 17 per cent more yield than the control, while with groundnut-cake supplying the same amount of N, the increase was only 6 per cent, when each was applied over a basal dressing

of cattle manure (5 tons) plus wild indigo (2,000 lb.) plus super (1 cwt.) per acre. Similar studies made at Samalkot over a period of three years also show that ammonium sulphate applied alone or in combination with cakes was definitely superior to cake only. At Palur, again, ammonium sulphate has proved best when applied with groundnut-cake to supply 100 to 150 lb. N in the ratio of 2 : 3, the increase in yield over control being over 50 per cent.

Passing on to cotton, ammonium sulphate (45 to 60 lb. N per acre) has been found to increase the yields considerably under irrigated conditions.

(2) *Sodium nitrate.*—When tried on rice on equal N basis (30 lb. N) sodium nitrate has proved ineffective. When compared with other nitrogenous manures in most of the Research Stations, it was found inferior to green leaf alone at Aduthurai and Coimbatore. With cattle manure under the same conditions it has given increased yields but not commensurate with its cost. It does not supplement cattle manure at Aduthurai. It was found to have a depressing effect, especially in the second year of its application in this locality. When applied in combination with simple artificials like ammonium sulphate to supply 30 lb. N on the whole, in varying proportions at Aduthurai, Coimbatore and Pattambi, the increases were less than 20 per cent only and in no case higher than those resulting from ammonium sulphate alone. The nitrate has also harmful effects on the soil texture causing deflocculation of the clay, and tending to promote alkalinity due to the sodium-ion. Soda nitrate also inhibited the beneficial effects of super at Coimbatore. On the potato crop it was not found quite useful.

On the whole, sodium nitrate has been found inferior to ammonium sulphate apart from its harmful effect on our soils.

(3) *Ammonium nitrate.*—This is one of the most concentrated nitrogenous fertilisers containing 35 per cent of N—half as nitrate N and half as ammoniacal N. It however, absorbs moisture and is subject to explosion hazards under certain conditions of storage. The results of the experiments on rice carried out with the fertiliser at the several Agricultural Research Stations show that it is in no way superior to ammonium sulphate when applied on equal nitrogen basis. In combination with green manures it has responded well like the other nitrogenous artificials, particularly ammonium sulphate.

(4) *Calcium cyanamide.*—This fertiliser though it contains as much N as ammonium sulphate (18–21 per cent) is not so widely used in our country. Its behaviour towards crops like rice is rather erratic and inconsistent. At Coimbatore it depressed the yield of rice in one field while benefiting it in another. At Manganallur it proved far inferior to ammonium sulphate and green leaf, giving only 2 per cent increase as against 15 per cent and 13 per cent respectively for the latter. It did not supplement

green leaf at Nandyal. At Coimbatore, however, it was useful in combination with super or green leaf. The fertiliser had sometimes depressing effects at Manganallur. At Koilpatti it gave excellent results with sorghum and bajra and interacted very well with super, giving 50 per cent increase on the latter crop. It was even better than fish manure. On ragi and chitrai cholam at Coimbatore, it was useful in 2 cwts. dose (18 per cent increase) but there was depressing residual effect (—8 per cent). On irrigated cotton, cyanamide did not respond in garden lands at Coimbatore, alone or with super.

2. *Phosphatic manures.*—The phosphatic manures in common use are superphosphate, bone-meal, rock phosphates and basic slag. Other forms of phosphates containing nitrogen in addition such as ammophos, leuno-phos, niciphos, etc., are also of late coming into prominence.

Experiments with phosphatic manures in the State are few and they are mainly confined to rice and potato. Other crops like cotton, sorghum, bajra and minor millets have received some but rather scant attention. The phosphatic manures like super bone-meal, rock phosphate, kossier phosphate, etc., when tried alone at 30 lb. level of phosphoric acid (P_2O_5) on rice at Coimbatore and Aduthurai have not shown any appreciable increase in yield. The only exception was at Manganallur where increasing doses up to 300 lb. of super per acre gave increases up to 30 per cent. Bone-meal also acted well with increasing doses but far less efficiently, while mineral phosphates had no effect at all. The value of these slow acting phosphates is not felt in the year of application but their residual effect manifests itself in later years. Of the various phosphatic manures in use, bone-meal and rock phosphate can be had locally in good amounts and they can after proper processing be used profitably for our crops. The normal estimated production of bones in the State is about 1·5 lakhs of tons. About a fifth of this is actually collected. The phosphatic nodules of Tiruchirappalli containing about 25 per cent P_2O_5 form another potential source of P. The estimated quantity of this phosphate is eight million tons. The phosphoric acid in the Tiruchirappalli nodules is, however, in an insoluble form and apart from the cost of sulphuric acid required, the mineral contains too much of lime and iron to make the manufacture of super from the nodules, economical. Various attempts have been made to utilize this phosphoric acid in the laboratory and in the field. The laboratory investigations studied the effect of various solvents and it was established that when it was ground into fine powder and made into a compost with green manure, the phosphate was rendered available. This was followed by pot experiments and then by field trials and finally it was concluded that mineral phosphate ground as finely as possible is a suitable phosphatic manure for rice lands, when applied *along with decomposing organic matter, e.g., green manure.* By subjecting the raw phosphate to fusion

at high temperature (1,200° C to 1,400° C.), product with high citrate solubility (about 15 per cent) has been obtained at Bangalore and elsewhere. The comparative trials of this fused product and super on rice at Aduthurai did not reveal any significant difference in yields. Composting of rock phosphate with sulphur increased the availability of phosphoric acid but this has not been found economical.

All the phosphatic fertilisers are best applied in combination with other manures. A mixture of green leaf and bone-meal or better, super, has given excellent results whereever phosphates deficiency was indicated. There are instances where super has so responded but not bone-meal. The application of these fertilisers by themselves to rice has given rather disappointing results, and cannot safely be recommended. They generally respond well in combination with organic or inorganic nitrogenous manures, e.g., ammonium sulphate, oil-cakes, green leaf, etc. The combination of super with cyanamide was useful at Coimbatore but not at Manganallur. Of the different types of phosphates tried, super has proved better when applied in combination with other nitrogenous manures, organic and inorganic. The usual dose of the fertiliser found economically efficient is about 1½ cwts. (30 lb. P_2O_5). Very good results have been obtained for rice in most parts of the State for the following combination of manures, resulting in an average yield of 2,500 lb. of grain per acre :—

Green manure 2,500 lb. per acre.
Super 1½ cwts. to supply 30 lb. P_2O_5.
Nitrogen—as cake to supply 15 lb.
Ammonium sulphate—N 15 lb.
Total N 30 lb.

The increases over control obtained from the above combination at several Agricultural Stations of the State were generally above 25 per cent.

On dry or garden lands, phosphatic manures in any form have in general, not given encouraging results. In presence of ammonium sulphate or cake, bone-meal and super, particularly the latter, have responded better than when either of these is applied alone. To achieve best results, a basal dressing of cattle manure (5 tons per acre) is recommended for all the tracts in the State. The experiments conducted in the Research Stations at Hagari, Koilpatti, Nandyal, Guntur and Coimbatore with sorghum, bajra and cotton have revealed that the use of artificial fertilisers supplying nitrogen and phosphorus in conjunction with bulky organic manures, such as cattle manure, has proved extremely beneficial with good residual effects lasting for two or three years especially in the dry land areas. The normal doses of manures found suitable for the different areas are super 1 cwt., ammonium sulphate 2 cwt. and cattle manure 3 to 5 tons per acre. In the case of rainfed cotton, the application of the manures to the previous cereal crop like sorghum or bajra has been found

advantageous both for the cereals and the cotton, the residual effect being felt even in the third year after the application of manures.

All these trials, in general, indicate the necessity for a judicious application of both phosphatic and nitrogenous manures in proper forms and adequate doses, preferably in presence of bulky organic manures, viz., cattle manure or green manure, depending on the relative needs of the various crops and the fertility of the soil. Application of phosphates alone is not advisable except perhaps in the case of leguminous crops which stand to benefit by such application, resulting in greater fixation of atmospheric nitrogen and higher yield of green matter which are very valuable for enriching soil fertility and increasing crop production.

The experiments on potato go to show that phosphates are essential for increased yields of tubers in the Nilgiris. The trials with different kinds of phosphates such as concentrated super, bone-meal, etc., in varying doses and in conjunction with nitrogen at the Agricultural Research Station, Nanjanad, have revealed that maximum yields of the crop up to 800 maunds (25 lb. per maund) per acre could be obtained with the higher doses of phosphates (200 lb. P_2O_5). The effect due to soluble forms of phosphates like super is more pronounced than for insoluble forms of the type of bone-meal. No trials have been conducted to study the individual effects of phosphates alone at Nanjanad, since it is well known that an adequate supply of nitrogen and potash is as much essential as phosphates for the production of a good crop of potato in the lateritic soils of the Nilgiris. As a result of a series of manurial trials conducted at the Agricultural Research Station, Nanjanad, with commercial fertiliser mixtures, such as those of Messrs. Parry & Company and Shaw-Wallace and other mixtures evolved by the department, the manurial requirements of potato have been worked out and a standard mixture under the name of " Nanjanad mixture " has been recommended. It has been possible to increase the yield of " Great Scot " at the Agricultural Research Station, Nanjanad, to an average of 15,000 lb. per acre through the use of this mixture. The ingredients used in the mixture and the proportions in which they are used are given below. As the ingredients are readily available in the market, it is quite easy for the ryots to prepare their own mixtures instead of resorting to the use of the more costly proprietary mixtures.

	Supplying quantities per acre of		
	N.	P_2O_5	K_2O
Groundnut cake 500 lb. ..	35	..	..
Ammonium sulphate 200 lb.	40	..	..
Steamed bone-meal 350 lb. ..	5	94	..
Concentrated super 336 lb...	..	140	..
Potassium sulphate 224 lb.	..	..	108

The Nanjanad mixture is best applied over a basal application of 5 tons cattle manure per acre. Consequent on the adoption of this

manurial schedule, the yield of potato at the Agricultural Research Station, Nanjanad, has gone up to 600 to 800 maunds (of 25 lb.) per acre.

3. *Potassic manures.*—The potassic fertilisers commonly in use are the sulphate and muriate of potash, and Kainit. Wood ashes of all kinds also form another important source of potash. In general, South Indian soils are well supplied with potash and are considered therefore not in need of this plant food element except in the case of sandy or highly leached soils and unless it be for crops like plantains, tobacco, potato and other tuber crops whose potash requirements are rather high. Potassic fertilisers have been found indispensable for securing good yields of potato in the Nilgiris. In the whole rice area of this State, potash manuring was not found useful. In some cases it was found to depress the yield of rice. On sugarcane again, its depressing effect was noticed at Samalkot. In stray cases it increased the yields of Cambodia cotton, but in these instances, potash deficiency was indicated. Wood ash (20 lb.) and cattle manure (100 lb.) per tree per annum were also found to beneficial to coconut trees in the West Coast.

4. *Lime.*—Lime has been found necessary for certain types of soils, especially, those which are acidic. Its beneficial effects lie in the flocculation of clay and the improvement in the physical condition of the soils apart from correcting soil acidity. On both rice and sugarcane crops liming was sometimes beneficial, sometimes not, depending on the soil and other conditions. At the Betelvine Experimental Station at Vellalur, liming improved the drainage of the heavy soils and resulted in higher yields. In a small check experiment at Coimbatore, it increased the yield of cotton by 30 per cent in an alkaline field. Its beneficial effects in this direction deserve more extended trials. Its behaviour in relation to soil deficiency is peculiar. In Nanjanad, for example, where the soil is exceptionally poor in lime, its application has not proved successful. However, maximum yields of potato were obtained from plots that received the full dose of cattle manure, lime and artificials both during the main and second-crop seasons. Even on the laterite soils of the West Coast, liming has not behaved consistently and more work is needed to assess its beneficial effects on this soil.

5. *Other miscellaneous manures*—(1) *Sewage and activated sludge.*—The efficient utilisation of sewage from town and cities can be effected by the use of the activated sludge process. The plant necessary for this purpose being rather costly, only big cities with sufficient financial resources can afford to have it installed. In this method the sewage nightsoil mixture is subjected to powerful æration and a coagulam free from bad smell and of high manurial value is obtained. The sludge contains about 4 per cent N. The effluent which contains nitrates may be diluted with water and used for irrigation.

The experiments conducted with effluent from the activated sludge plant of the Agricultural College Estate at Coimbatore and ordinary channel water from 1934–35 to 1939–40 in the Central Farm wet lands have not shown any beneficial effects due to effluent. On the other hand, the use of raw sullage water from the Agricultural College Estate without admixture of fæces increased the yields of rice by 17 per cent over control. No field experiments have been conducted with the activated sludge on rice or other crops in the State but the trials carried out at Rothamsted and other places go to establish the high manurial value of the activated sludge for various crops.

(2) *Slaughter-house wastes, tannery refuse, etc.*—These include mainly dried blood which contains 12 to 15 per cent nitrogen of high availability, horns, hoofs, hair, leather shavings, etc. Practically no manurial experiments involving the use of these materials have been conducted in this State. Leather fleshings and other waste materials from tanneries are very slow in decomposing and are not of much direct manurial value in their raw state. They may at times even prove injurious to plants due to their admixture with such harmful substances as chromates used in tanning. These materials have to be subjected to processing by the use of steam and acids before they are converted to useful manures. Tannery refuse is being converted into compost by burying it in the soil with lime and then applied as manure.

(3) *Salt and salt earth.*—These are commonly used in the West Coast from time immemorial as manure for coconuts and also as a protective against insect attacks to young seedlings. The application of salt is believed to induce early bearing in coconut trees and is quite common in the West Coast. But experiments have shown that the application of salt was not advantageous.

(4) *Mill wastes.*—These when converted into composts with the addition of cattle manure and red earth and applied to the fields at the rate of 50 to 70 cart-loads per acre have considerably increased the yields of crops, particularly ragi at Coimbatore. The N content of the blow room waste varies from 1·39 to 2·09 per cent while P_2O_5 and K_2O contents range from 0·44 to 0·67 per cent and 1·4 to 1·55 per cent respectively.

(5) *Press mud.*—Press mud is the solid matter obtained in the clarification of cane juice in sugar factories. This residue contains 1 per cent N, 2 per cent P_2O_5, 0·5 per cent K_2O and 10 per cent lime. It is rich in lime and is used as manure. It has also been used with success for composting cane trash in place of dung.

(6) *Rice husk and chaff.*—The husk is sometimes used in heavy soils, particularly paddy soils for improving drainage and the ash is a source of potash. Substances of these types being inferior in manurial value are of secondary importance only.

A list of some of the common inorganic and organic manures together with their analysis is given in the statement at the end of this chapter.

Crops in Relation to Manuring.

1. *Rice.*—A good number of systematic manurial experiments has been conducted on this all-important crop in the Agricultural Research Stations of the State, viz., Anakapalle, Samalkot, Maruteru, Aduthurai, Coimbatore, Pattambi and also in recent years at Pattukkottai and Tirurkuppam. These trials relate to the study of the effects of different nitrogenous and phosphatic manures applied individually and in combination.

(*a*) *Nitrogenous manures.*—It is a well-established fact that the rice plant responds well to nitrogen in the form of ammonium sulphate, oil cakes or green manures. The beneficial effect of nitrogenous manures on rice in the State is very striking. The normal dose of nitrogen required lies somewhere about 30 lb. the percentage increases ranging generally from 25 to 40 depending upon the nature of manure, the locality and the strain. The optimum dose appears to be 150 lb. of ammonium sulphate or 425 lb. of groundnut cake to supply 30 lb. N. All kinds of cakes can be used with equal advantage on the same nitrogen basis. The application of green manure in varying doses 2,000 to 8,000 lb. per acre has increased the yields of both first and second crops according to the quantity of the manure applied. The optimum dose for all the stations appears to lie between 4,000 to 6,000 lb. per acre, the percentage increase in yields varying generally from 15 to 45 over control. The maximum response (40 to 50 per cent) was noticed with an application of 6,000 to 8,000 lb. in the case of the Circars, West Coast and Cauvery–Metter Project area soils. At Tirurkuppam, extremely striking results have been obtained, the increases recorded being 52 per cent for *samba* and more than 100 per cent for *swarnavari* over the respective check plots. In the case of oil-cakes also, a progressive response has been noticed with incremental doses of N up to 60 lb. resulting in increased yields of about 40 to 50 per cent over the normal. Among the artificials, nitrate of soda has proved ineffective when compared with other nitrogenous manures, particularly ammonium sulphate, in most of the stations. The bulky organic manures, viz., cattle manure, molasses and composts have been tried for periods up to five years in a few stations (Aduthurai and Pattambi) with no appreciable increase in yields, except perhaps with cattle manure, to supply 30 lb. N at Pattambi. Increase in yield ranging from 14 to 20 per cent was obtained at the latter station.

(*b*) *Combination of nitrogenous manures.*—Experience has shown that the combined application of organic and inorganic manures at the several Agricultural Stations has proved more beneficial than either of these applied alone and the effect has been particularly marked in a few localities as at Pattambi and Maruteru. The results from the trials at the different stations show that a judicious combination of organic and inorganic manures, viz., green leaf at 4,000 to 5,000 lb. plus ammonium sulphate 75 lb. (15 lb. N) or oil-cake to supply 30 lb. N plus ammonium

sulphate 75 lb. (15 lb. N) is best suited for rice. In no case should a combination of artificials alone be restored to for ricè; an adequate supply of organics must be ensured to obtain maximum benefit from artificials.

(*c*) *Phosphates*.—Phosphate being an essential plant nutrient for the production of good quality grain, its application in adequate amounts and in proper forms to soils deficient in this constituent would appear to be necessary though the actual data from phosphate applications are not quite encouraging. Phosphatic manures like super, bonemeal, bone jelly, Kossier phosphate, etc., when applied individually at 30 lb. $P_2 O_5$ level in a few stations, viz., Coimbatore and Aduthurai, have not shown any appreciable increase in yield, the maximum ever met with being about 17 per cent over control at Coimbatore while at Aduthurai, the percentage increases have fluctuated between five and eleven. The behaviour of phosphates by themselves towards rice as already stated, has been rather erratic. Phosphatic manures, in general, respond better in combination with organic or inorganic nitrogenous manures, such as green leaf, ammonium sulphate, oil cakes, etc. Over and above the effects of the N in these combinations, the inclusion of phosphates has not been very helpful from the point of view of yield. All the same, this does not minimize the importance of phosphate application to rice soils of this State which are likely to be depleted further of this important plant food by intensive and continuous cropping in the years to come. For the maintenance of soil fertility and normal crop production, it is absolutely necessary to resort to periodical addition of phosphates preferably in conjunction with bulky organic manures.

In general, the best combination of manures for rice to ensure an average yield of 2,500 lb. grain per acre is super $2\frac{1}{4}$ cwt. (30 lb. green manure (2,500 lb.), ammonium sulphate and cake, $P_2 O_5$ each to supply 15 lb. N. With regard to the time of application of the manures, the experiments at the several stations have shown that the application of ammonium sulphate or cake one month after planting over a basal application of green leaf gives the best results. As for super, it has been observed that its addition in a single dose at 30 lb. phosphoric acid level before planting, at Coimbatore, gave an increase in yield of 17 per cent over control (2,400 lb. grain).

The expected yields in pound for the doses of N (0 to 60 lb.) per acre supplied as cakes in the select Agricultural Research Stations of the State, culled out from Dr. Stewart's "Report on Soil Fertility Investigations in India with special reference to manuring (1947)" is presented in the statement III appended.

2. *Sugarcane*.—Sugarcane ranks high among the crops of economic importance in this State and in view of this, considerable attention has been devoted to the manurial requirements of this crop.

Manurial experiments have been in progress for the last two decades on the crop, mainly at Anakapalle and Samalkot in the Circars, at Palur in South Arcot, and at Coimbatore in the Central districts. The studies have hitherto been confined to investigations on the nature and quantity of nitrogen required for this crop and the best time of application of the manures. It has been definitely established that the application of nitrogenous manures increases considerably the tonnage of the popular varieties of canes tested. Phosphates though not striking in their effects or needed in such high doses as N have been found to influence the quality of jaggery. At Anakapalle, the relative merits of groundnut cake (640 lb.) and ammonium sulphate (260 lb.) on equal nitrogen basis over a basal dressing of cattle manure (5 tons) plus wild indigo (2,000 lb.) plus super (1 cwt.) per acre were investigated. An increase of 17 per cent over groundnut cake plots was obtained for the series treated with ammonium sulphate. Similar studies made at Samalkot also show that the crop responds better to ammonium sulphate than to groundnut cake only. Again, in the experiments conducted with promising types of canes at Anakapalle and Samalkot to find out the optimum doses of nitrogen supplied half as cake and half as ammonium sulphate, the doses ranging from 50 to 200 lb. nitrogen per acre, increased yields were obtained with the higher doses of nitrogen, particularly 75 lb. and 100 lb. At Samalkot the increases due to 150 lb. and 200 lb. are not striking when compared to 100 lb. nitrogen. Co. 419 yielded 59 tons of canes with 50 lb. nitrogen and 72 tons with 150 lb. nitrogen and the increases were significant.

Trials were made for six years at Palur varying the quantities of nitrogen (50 to 200 lb.) and the proportions of cake and ammonium sulphate in the manure. The application of cake and ammonium sulphate to provide 100 lb. nitrogen in the proportion of 4 : 1 or 3 : 2 was found best and economical. The increases for the two proportions were 40 and 52 per cent respectively over the 50 lb. groundnut cake nitrogen. Progressive increases were noted with increasing doses of nitrogen.

In another experiment over a period of six years the comparative merits of sodium nitrate and ammonium sulphate applied as nitrogenous fertilisers in conjunction with cake to supply 200 lb. nitrogen in the aggregate, as well as their interaction with phosphates (super) and potash (potassium sulphate) in relation to yield and quality of Fiji B. cane were studied. Significant results were obtained with cake alone or in combination with ammonium sulphate. With addition of super (100 lb. P_2O_5) and potassium sulphate (50 lb. K_2O) the response due to nitrogen supplied as cake and ammonium sulphate in the proportion of 3 : 2 was the highest with an yield of 24 per cent over the plots receiving 200 lb. nitrogen as sodium nitrate. Sodium nitrate. applied by itself or together with other fertilisers, viz., super and potassium sulphate in any proportion caused a marked depression in all the years. In the permanent manurial experiments at

Coimbatore the effects of artificials, viz., ammonium sulphate (1 cwt.) potassium sulphate (1 cwt.) super phosphate (3 cwt.) cattle manure (5 tons) direct and residual—applied alone and in combination were studied. The percentage increases in the several cases varied from 28 to 150 per cent, the best treatments (100 per cent and above) being N + K + P, and N + P (N = Nitrogen; K = Potash; P = Phosporic acid).

Molasses supplying nitrogen from 26 lb. to 78 lb. was compared with similar doses of nitrogen applied as ammonium sulphate, green leaf (pillipesara) or groundnut cake at Anakapalle. The results from molasses application were not encouraging.

Time of application.—The experiments in connexion with the time of application of quick-acting manures like oil cakes and ammonium sulphate were carried out at Palur for over six years. The application of the manures in two doses, one at the time of planting and the other at the time of earthing up has been found definitely advantageous. Nitrogen applied as groundnut cake and ammonium sulphate in the proportion of 3 : 2 in two doses has given 9·7 per cent more yield than the single dose.

Seed-bed manuring.—This investigation was undertaken at the Agricultural Research Station, Gudiyattam, with the object of comparing the behaviour of seed material raised in intensively and poorly fertilised plots (intensive dose 20,000 lb. cattle manure plus 2,000 lb. groundnut cake plus 400 lb. ammonium sulphate plus 400 lb. super plus 100 lb. potassium sulphate; poor dose—10,000 lb. cattle manure only). When planted out in fields treated with normal dose of manures (150 lb. nitrogen, half as groundnut cake and half as ammonium sulphate) and 2/3rds and 1/3rd normal doses, a progressive increase in yield with increase in the amount of nitrogen supplied to the main field has been recorded for both the seed-bed treatments. The intensively fertilised seed material has responded more favourably to all doses of nitrogen than the poorly fertilised seed material. Indirectly, these manurial trials have revealed the beneficial effects of farmyard manure in improving the general character of the soil and enriching the quality of the juice and improving the jaggery obtained. Though the inorganic fertilisers contribute to the increase in tonnage, they are not effective in improving the quality of the juice. A basal dressing of farmyard manure is desirable not so much for its nitrogen content as for its effect on the quality of juice which is much improved by such an application.

From a general consideration of sugarcane manuring in all tracts, the dose of nitrogen is the most important point to be considered. Phosphates are not very helpful but a small quantity seems to be necessary from the point of view of quality of jaggery. The form of nitrogen whether as cakes or ammonium sulphate or fish guano, does not appear to influence the yields to any appreciable extent, the differences observed between them being within narrow limits. Cattle manure is not useful in increasing the yield except perhaps

at Anakapalle and even here cakes can replace it equally well. Its addition is, however, recommended for improving the quality of the juice. Ammonium sulphate, especially in high doses, seems to delay ripening and adversely affect the quality of jaggery.

3. *Bananas.*—This is another commercially important crop grown mostly in wet lands and garden lands under heavy irrigation. Its distribution is mainly restricted to the deltaic tracts in the Circars and Tiruchirapalli and Tanjore districts. Scattered areas under this crop are also met with in the districts of Coimbatore and Malabar under irrigated and rainfed conditions respectively.

The manurial experiments conducted for some years at Palur and Samalkot Research Stations have brought out the importance of nitrogen and potash for the crop. Potash in the form of potassium sulphate or ashes would appear to be necessary besides ammonium sulphate or cake and super for good yields. The optimum dose recommended is potassium sulphate (1½ cwt.) plus groundnut cake (5 cwt.) plus super (2 cwt.) per acre for the Palur tract and ammonium sulphate 2½ oz. plus potassium sulphate 2½ oz. plus super 3½ oz. per tree for the Samalkot area. The keeping quality or the flavour of the fruits does not appear to be influenced by potash.

4. *Garden crops*—(*a*) *Cereals and cotton.*—The manurial trials on these crops are few compared to those on rice or sugarcane. The available data show that nitrogenous and phosphatic manures have beneficial effects on these crops. Application of bulky organic manures, particularly cattle manure, has proved best for all garden land crops. At Coimbatore, it has shown itself equal to complete chemical manure (N plus K plus P) in shape of artificials throughout of period of study. Experience at the Central Farm has demonstrated that it is possible to maintain a high standard of yield on garden land by the application of cattle manure alone. Nine cart-loads per acre applied to cotton at the Cotton Breeding Station gave 18 per cent higher yield.

Green manure grown *in situ* and ploughed in, yielded 16 per cent more of cotton than the control plots.

From a statistical examination of the yield data from the permanent manurial experiments (old and new) Central Farm, Coimbatore, involving trials on various garden land crops and the application of cattle manure and artificials (*N*, *P*. and *K*) singly and in various combination, the following conclusions may be drawn :—

(i) Regular application of cattle manure can give as good yields as from any other combination of inorganic fertilisers.

(ii) For maximum crop production either cattle manure or complete artificials supplying *N*, *K* and *P* are desirable.

(iii) Potassic manures are not found essential for the cereal crops studied so far.

It is also interesting to note in this connexion that the general trend of results obtained in these experiments is similar to that

noticed at Rothamsted. Apart from permanent manurial experiments at Coimbatore very few systematic manurial trials have been conducted in the State on cereals other than rice. Recent experiments with cotton have indicated the beneficial effects of ammonium sulphate when applied to supply 45 to 60 lb. nitrogen per acre.

(*b*) *Groundnut.*—This is one of the major crops of economic and industrial importance in the State. This is extensively cultivated in South Arcot district under irrigation, either pure or mixed with ragi. Manurial experiments on this crop were mainly conducted in the earlier years at Palur and later at Tindivanam. Being a leguminous crop capable of fixing atmospheric N, it can be expected to establish itself well under normal conditions in light sandy soils provided lime, phosphates and other essential ingredients are present in the soils in sufficient quantities. The manurial problem with this crop did not present much difficulty in the earlier years. Later, however, continuous cultivation of the crop in the same land affected the yields and application of manures had to be resorted to keep up yields. At Palur it was noticed, that application of super 1 cwt. per acre plus 2 cwt. ammonium sulphate increased the yield by about 20 per cent over the control (1,130 lb. pods per acre). Significant reuslts were also obtained at Tindivanam in favour of the combination of artificials N - 1 + P Basal dressing of cattle manure at three tons per acre did not have much effect on yield.

5. *Dry land crops.*—Manuring of dry land crops did not receive much attention because of its doubtful value, especially under restricted conditions of moisture and vagaries of season. The common dry land crops of the State are cotton and millets confined mostly to the Ceded districts, while chillies, tobacco and groundnut are cultivated in Guntur. In the southern districts of Tirunelveli and Ramanathapuram bajra, sorghum and cotton are raised as dry crops.

(*a*) *Cotton.*—The experiments carried out at Guntur, Nandyal, Hagari and Koilpatti have all shown that artificial fertilizers ammonium sulphate (2 cwt.) and super (1 cwt.) with groundnut cake (250 lb.) or cattle manure (6 cartloads) per acre would answer the needs of the crop in the Ceded districts area and the black soil tracts of the southern districts. The increases obtained ranged from 20 to 40 per cent in the Ceded districts while at Koilpatti the response was phenomenal, the increase being above 100 per cent in most cases. It is interesting to note, further, that the application of manures to the previous cereal crop, viz., sorghum, bajra, or tenai, benefited without exception the succeeding cotton and cereal crops, the residual effects being felt even in the third year after application of the manures.

(*b*) *Sorghum.*—Manurial trials on this rainfed crop have been conducted at Guntur, Hagari, Nandyal and Koilpatti, the same types and dosages of manures as for cotton being applied. Very good increases, 50 per cent over control, have been obtained in all

the centres. The highest yield recorded for the full combination of artificials was more than 300 per cent at Koilpatti when these were applied over a basal application of cattle manure at two cartloads.

In addition to these artificials, green manures of different types, viz., *Pillipesara, Teegapesara* and cowpea were tried at Guntur, each supplying 55 and 84 lb. of N. All the manures, especially cowpea, have given higher yields of sorghum (40 to 60 per cent). The addition of super to these manures was not particularly advantageous.

(*c*) *Minor millets.*—*Tenai, samai, maize, varga, bajra* and *panivaragu* coming under this group do well with an application of farmyard manure or compost supplying 50 lb. nitrogen with or without the addition of artificial fertilisers. In regard to bajra which forms one of the important minor millets of the southern districts of Tirunelveli and Ramanathapuram, phenomenally high increases (above 100 per cent) were obtained with ammonium sulphate (2 cwt.) or groundnut cake (500 lb.) plus super (1 cwt.) and three tons of compost or farmyard manure. Green manures, viz., *pillipesara, teegapesara*, and cowpea applied as for sorghum with and without super also gave significant results at Guntur with an average increase of about 50 per cent over control. As for *samai* cultivated in the Nilgiris, it is not directly manured but grown in rotation with potato which is fertilized heavily. Direct manurial effects on this crop have shown that ammonium sulphate (1 cwt.) or niciphos (1½ cwt.) per acre was as good as Nanjanad mixture containing both organic and inorganic ingredients providing *N, K* and *P*.

(*d*) *Groundnut.*—The application of five cartloads of farmyard manure per acre has proved beneficial at Nandyal resulting in an increased yield of 25 per cent over control (1,360 lb. per acre).

(*e*) *Chillies and tobacco.*—A full combination of ammonium sulphate (2 cwt.) potassium sulphate (100 lb.) super (2 cwt.) over a basal dressing of cattle manure at four cartloads per acre has been found very effective in increasing the yields of these crops in Guntur.

(*f*) *Pepper.*—The cultivation of pepper is restricted to the hilly tracts of Malabar and the manurial experiments on this crop are very few. Being a perennial crop, it is rather difficult to assess correctly its manurial needs at the various stages of growth. From the experiments conducted at Taliparamba, it is found that the application of ammonium sulphate, potassium sulphate and super (¼ lb. each) with leaf mould 20 lb. and lime ½ lb. per vine is best suited to the crop.

(*g*) *Coconuts.*—Manurial experiments on coconuts have been in progress at the coconut research stations, Kasaragod and Nileshwar from 1922 onwards. They mostly aimed at studying the response of coconuts to the application of organic and inorganic manures such as fish guano, cattle manure, ammonium sulphate,

super phosphate, potassium sulphate, wood ash, etc. The results indicate that the best application for coconuts under West Coast conditions is ammonium sulphate 3 lb. plus ashes 20 lb. plus cattle manure 100 lb. per tree. It is preferable to broadcast the manure and plough it in.

(*h*) *Potato.*—Of all the crops potato has been found to respond to manuring exceedingly well. The cultivation of the crop is confined mostly to an area of about 13,000 acres in the Nilgiris. Experience at the Agricultural Research Station, Nanjanad has shown that intensive manuring with artificials, viz., super, bonemeal, sulphate of ammonia and potash in combination with organic manure in the form of cake preferably over a basal application of cattle manure is absolutely necessary for raising a good crop of potato. As a result of a series of trials, a standard mixture called " The Nanjanad Mixture " mentioned already, has been prescribed.

The manurial trials with the main (March to September) and second crop (August to December) indicate definitely, that as regards phosphoric acid and potash, the optimum requirement of potato is met by 3 cwt. of concentrated super and 1 cwt. of sulphate of potash per acre. The investigations on the effects of inorganic and organic nitrogen on the crop have revealed that the combination of organic nitrogen in the form of groundnut cake (500 lb.) and inorganic nitrogen in the form ammonium sulphate (2 cwt.) or nitrate of soda in equivalent amount responded better than inorganic N. alone, the yield resulting from the application of the combination of manures being alike about 700 mds. (25 lb. each) per acre against 650 maunds for the inorganic nitrogen only. Experiments were also carried out to test the efficiency of " *Farm Mixture* " with other mixtures supplying an equal amount or half as much of phosphoric acid either as super or as bonemeal. These mixtures had the other ingredients just as in Nanjanad Farm Mixture. The trials were with both the main and second crop potato and the observations made are (1) between half and full doses of phosphates significant results were obtained with the full dose. (2) Mixture with super as the sole carrier of phosphoric acid behaved just like the Nanjanad mixture, and (3) mixture with insoluble phosphate was definitely inferior to the farm mixture or the mixture with super as the phosphate supplier.

Again, from the permanent manurial experiments conducted on the main and second crop potatoes to test the effect of artificials N, K and P (N groundnut cake 500 lb. plus ammonium sulphate 200 lb.; K-potassium sulphate 2 cwt.; P-concentrated super—3 cwt. plus steamed bone meal 350 lb.) in presence and absence of lime (2 tons per acre) or cattle manure 5 tons the following salient points are evident :—

(1) Nitrogen by itself has not given any response.

(2) Nitrogen with *K* or *P* or *K* + *P*, has increased the yield considerably, the maximum increase being with N plus P and N

plus K plus P (509 mds. and 571 mds. of 25 lb. each respectively) with an increase of about 400 per cent over the control yield of 103 mds. per acre.

(3) Phosphate alone is significantly better than control.

(4) N plus P plus K in combination with cattle manure or lime has acted better than when alone.

(5) No difference was observed between lime and cattle manure plots but for a slight increase in favour of the latter during the second crop season.

(6) Maximum yields were obtained from plots that received the full dose of cattle manure, lime and artificials both during main and second crop seasons.

Further comparative trials of the farm mixture with commercial fertilizer mixtures from recognised firms at different N levels (87 lb. and 116 lb.) with and without cattle manure both on the main and second crop potato definitely established the superiority of the farm mixture over the others.

The studies with different phosphates, viz., super, steamed bone meal, dicalcic phosphate and precipitated phosphate, substituted in the Farm mixture and applied at two levels of P_2O_5 (phosphoric acid) (full and half doses) to the main and second crops show that—

(1) Lime has no beneficial effect.

(2) Steamed bone meal is definitely inferior to the more soluble forms of phosphoric acid.

(3) Both in the limed and unlimed series full doses of phosphate are better than the corresponding half-doses.

(4) The Farm mixture with mono and dicalcic phosphate is as good as mixtures containing concentrated super or dicalcic or precipitated phosphate.

Among the different oil cakes, viz., black castor, white castor, coconut, *neem* and *pungam* cakes substituted for groundnut cake, in the farm mixture, *Neem* was significantly inferior to others all of which behaved almost alike in their effect.

Fish manure in increasing doses up to 15 cwt. per acre augmented the yield considerably and cattle manure at 10 tons per acre gave much better results than at five tons.

General Considerations in regard to manuring in the Madras State.

From the results of the several experiments conducted in the various parts of the State, it is possible to indicate the general requirements in regard to manuring of different crops. A common feature of the experiments is the large variability of the increases got by manuring in the same locality and even in the same fields. To get the best value therefore out of the manure it is always preferable to distribute it in poor fields, and if indications could be got, in poorer portions of the same field. The advantage will be that one will be able to cover a larger area with the same quantity of manure.

Notwithstanding the variability due to season and variations in soil fertility mentioned above, it is possible to give an indication as to the value of the manure in various localities and on different crops. A summary of results giving the manures and the dosages recommended for the various crops with reference to localities represented by the different Agricultural Research Stations in the State, is given in Statement IV. The recommendations made are based on actual field trials which have been carried out for a sufficient number of years in the various centres and are statistically trustworthy. They can generally be relied on to give the broad effects of manuring at the places mentioned. It is also reasonable to expect more returns from these manures on ryots' lands in the surrounding locality than at the departmental farms where they were tried. This is because in a large majority of cases the farms originally possessed or were subsequently brought to a much higher level of fertility than the surrounding tracts. This is especially true of the Farms at Anakapalle, Coimbatore, Samalkota, Aduthurai and Pattukottai.

The findings from the manurial trials further reveal that the requirements of our State in the order of importance in regard to manurial constituents are (1) organic matter, (2) nitrogen and (3) phosphoric acid.

The extensive soil surveys conducted by the Agricultural Department also point to the poverty of large tracts of land in the above three constituents. The most successful manures have been green manures (sometimes with phosphates) in rice lands, cakes and ammonium sulphate in sugarcane lands and the cattle manure for all garden and dry crops. These results bring home the vital importance of organic matter in any system of manuring in our State. The superiority of cattle manure over artificials has been brought out by the researches in the Agricultural Chemistry Section of the Department. The results of the investigations go to show that cattle manure conserves fertility better than artificials and produces seeds of a higher cropping and nutritive value. These findings which are being disputed by workers elsewhere, have to be confirmed by further systematic and intensive experiments on a variety of crops grown under different environmental conditions. Moreover, it is found that the residual effects of cattle manure last much longer. The chemical analysis of the soils in the permanent manurial plots at Coimbatore, and the green manurial experimental plots at Anakapalle, has shown, that even after twenty years of manuring with cattle manure and green manure in the two centres respectively, there has not been an appreciable increase in the organic matter content of the soils. The investigations by a number of workers on tropical soils (including those conducted at the Research Institute at Coimbatore) show that 12 to 50 per cent organic matter is being lost in a period of six to twelve months depending on the nature of the added material. That this is true of paddy lands also has been shown by the researches on the decomposition of green manure in

rice fields where large proportions of the nitrogen and carbon of the green leaf were found to be lost under swampy conditions. These results emphasise that in any system of manuring meant to maintain good yields, organic matter has to be kept continuously supplied to the soil. This naturally brings into prominence the value of bulky organic manures for the soils of the State.

The results of the manurial trials also show that artificials have to be used in conjunction with organic manures to get the best results. The only artificials that have proved popular and beneficial are ammonium sulphate and superphosphate for almost all crops. But unfortunately super is generally unable to act well alone and requires supplementing with organic manures to give maximum benefit. Here again organic manures as green manures or cakes are more important and in such cases even bone meal acts beneficially. It is also likely that bone meal could be made more available by preparing it in a finer condition. Except perhaps ammonium sulphate the behaviour of other nitrogenous artificials tried, viz., sodium nitrate and cynamide has not been encouraging. In many cases, there were bad residual effects. It is also doubtful, whether we can maintain good yields for a long time with artificials alone. The indications are that the yields will go down by their continuous use, while the soil also will be adversely affected. Our best course, therefore, will be to use artificials only on basal doses of cattle manure or other bulky organic manures. This procedure is necessitated by the present supply of cattle manure which is very inadequate to meet the demand. The burning of cattle dung for fuel purposes and the failure to collect and store it properly are some of the causes contributing to this deficiency. To remedy this evil all available resources for increasing the supply of organic matter to the soil have to be exploited. The value of green leaves, waste straw, nightsoil, slaughter-house wastes, urban and farm wastes has to be fully realized and all these materials should be utilized to the best advantage. The remedy at present lies in making more extended use, wherever possible, of green manures, preferably leguminous types raised with the application of phosphates and also in the preparation of composts on an extensive scale throughout the country from waste materials, nightsoil, etc.

Even when full attempts are made to conserve and utilize all available supplies of organic matter the quantity will not be sufficient to meet the needs of more than a fraction of the cultivated area. If our country is to be self-sufficient with regard to its food requirements, increased use of artificials will have to be made. A glance at the figures relating to the production and consumption of chemical fertilizers in various countries of the world is enough to show that acre yields of crops run somewhat parallel to the consumption of fertilizers. It is essential to step up the production of artificials, especially nitrogenous fertilizers, by setting up a few more factories like the one at Sindri. It is well to remember, however, that to secure the best results, artificials should be used in conjunction with organic manures.

Legislation for ensuring price and quality of manures.—In order to ensure the quality and fair price of different manures marketed in this State, Government passed in 1950, an order known as the "Madras Manure Mixtures Quality and Price Control Order." By this order, only firms of standing, approved by the Director of Agriculture on the recommendations of the Fertilizers Advisory Committee, shall manufacture and sell manure mixtures. These firms are further enjoined by this order, to state the price and percentage composition of the mixtures on these bags, which must be sealed. The prices are fixed by the Director of Agriculture, after taking into consideration the prices of the individual ingredients in the mixture and the declared maximum price so approved by the Director, shall be the maximum price at which the manure mixture may be sold. A special post—(The Inspector of Fertilizers) was sanctioned in 1950, with the necessary staff, to obtain samples from the factories of producing firms and to carry out the analysis of such samples to check with the guarantees given by the firms

Statement showing the expected yields in the select Agricultural Research Stations of the State for different doses of cake nitrogen.

State.	*Station.*	*Expected yields lb. for the doses (lb. nitrogen per acre) tried.* 0	20	40	60	*Remarks.*	
	Crop—Rice.						
MADRAS ..	Aduthurai	1,566	1,936	2,234	2,460	All cakes combined—Groundnut, Castor and Neem.	First crop.
		1,577	1,935	2,080	2,193	Do.	Second crop.
	Pattambi	1,508	1,706	1,871	2,005	Groundnut cake.	Do.
		1,498	1,753	1,895	1,926	Castor cake.	Do.
		1,498	1,735	1,924	2,065	Neem cake.	Do.
		1,696	1,829	1,971	2,121	All cakes combined.	First crop.
	Coimbatore.. ..	2,123	2,507	2,900	3,304	Do.	
	Maruteru	1,917	2,215	2,440	2,593	Do.	Second crop.
		2,687	2,985	3,076	2,959	Do.	Main crop.
		2,482	2,696	2,886	3,052	Do.	First crop.
		2,065	2,569	2,850	2,906	Groundnut cake.	Second crop, 1941–42.
		2,084	2,380	2,684	2,999	Castor cake.	Do.
		2,102	2,235	2,470	2,807	Neem cake.	Do.

Manurial recommendations for the important crops of the State.

Locality.	*Crop.*	*Manures recommended and dosage per acre.*
NITROGENOUS MANURES.		
Maruteru ..	.. Rice	.. Green manure 4,000 lb. or groundnut cake 675 lb. or ammonium sulphate 100 lb.
Samalkot ..	.. Do.	.. Green manure 6,000 lb. or ammonium sulphate 150 lb.
Anakapalle	.. Do.	.. Green manure 6,000 to 8,000 lb.
Aduthurai ..	.. Do.	.. Ammonium sulphate 150 lb. or green manure 4,000 lb.
Tirurukuppam	.. Do.	.. Green mnure 6,000 to 8,000 lb.
Pattukottai	.. Do.	.. Do.
Coimbatore	.. Do.	.. Ammonium sulphate 150 lb. or groundnut cake 425 lb. or green manure 6,000 lb.
Pattambi ..	.. Do.	.. Ammonium sulphate 150 lb. or groundnut cake 425 lb. or green manure 5,000 lb.
COMBINATION OF ORGANIC AND INORGANIC NITROGEN.		
Maruteru ..	.. Rice	.. Green leaf 2,000 lb. plus ammonium sulphate 100 lb.
Pattambi ..	.. Do.	.. 1. Green leaf 4,000 lb. plus ammonium sulphate 75 lb. 2. Castor cake 700 lb. plus ammonium suphate 75 lb. 3. Groundnut cake 425 lb. plus ammonium sulphate 75 lb. 4. Neem cake 500 lb. plus ammonium sulphate 75 lb.
NITROGEN AND PHOSPHATE COMBINATIONS.		
Samalkot ..	.. Rice	.. 1. Green manure 4,500 lb. plus super 167 lb. 2. Ammonium sulphate 150 lb. plus super 167 lb. 3. Niciphos 30 lb. nitrogen plus 30 lb. P_2O_5. 4. Green manure 2,250 lb. plus ammonium sulphate 75 lb. plus super 167 lb.
Maruteru ..	.. Do.	.. 1. Niciphos 44 lb. nitrogen plus 32 lb. P_2O_5. 2. Green leaf 2,000 lb. plus ammonium sulphate 160 lb. plus super 180 lb. 3. Groundnut cake 637 lb. plus flour phosphate 48 lb. P_2O_5. 4. Milled guano 32 lb. P_2O_5 plus groundnut cake 425 lb.
Aduthurai ..	.. Do.	.. 1. Ammonium sulphate 100 lb. plus super 75 lb.
	Do.	2. Green leaf 2,000 lb. plus super 112 lb.
Coimbatore	.. Do.	.. Green leaf. 4,000 lb. plus super 112 lb.
Pattukottai	.. Do.	.. Do.
Pattambi ..	.. Do.	.. Do.
Anakapalle	.. Sugarcane	.. Cattle manure 5 tons plus green leaf 2,000 lb. plus super 112 lb. plus ammonium sulphate 260 lb.
Samalkot ..	.. Do.	.. 1. Ammonium sulphate 500 lb. plus bone meal 224 lb. plus super 224 lb. 2. Groundnut cake 1,200 lb. plus bone meal 224 lb. plus super 224 lb.
Palur ..	.. Do.	.. 1. Goundnut cake, 1,000 lb. plus ammonium sulphate 100 lb. 2. Groundnut cake 800 lb. plus ammonium sulphate 200 lb.

Locality.	*Crop.*	*Manures recommended and dosage per acre.*
	NITROGEN AND PHOSPHATE COMBINATIONS—*cont.*	
Samalkot ..	.. Banana ..	Ammonium sulphate 2½ oz. plus potassium sulphate 2½ oz. plus super 2½ oz. per tree.
Palur ..	.. Do. ..	Potassium sulphate 168 lb. plus groundnut cake 560 lb. plus super 224 lb. per acre.
	RAINFED AND GARDEN LAND CROPS.	
Coimbatore	.. Cotton ..	1. Cattle manure 15 cartloads. 2. Green manure ploughed in situ (red soil). 3. Ammonium sulphate 336 lb. 4. Potassium sulphate 100 lb. plus super 336 lb.
Coimbatore	.. Cholam and Ragi.	Cattle manure 5 tons per acre.
Palur ..	.. Groundnut.	Super 112 lb. plus cattle manure 5 cartloads.
Guntur and Nandyal.	Cotton ..	Ammonium sulphate 224 lb. plus super 112 lb. plus cattle manure 5 cartloads.
Hagari ..	.. Do. ..	Compost and cattle manure at 50 lb. nitrogen (3 tons).
Koilpatti ..	.. Do. ..	Groundnut cake 259 lb. plus ammonium sulphate 112 lb. plus super 112 lb. plus cattle manure 3 tons.
Guntur, Hagari and Nandyal.	Sorgum ..	1. Ammonium sulphate 224 lb. plus super 112 lb. plus cattle manure 3 tons. 2. Green manure, cowpea, ploughed *in situ*.
Koilpatti ..	.. Do. ..	Groundnut cake 500 lb. plus super 112 lb. plus cattle manure 2 tons plus cotton compost 1 ton.
Hagari ..	.. Tenai ..	Cattle manure 6,000 lb. (50 lb. nitrogen).
Koilpatti ..	.. Bajra ..	Ammonium sulphate 224 lb. plus super 112 lb. plus cattle manure 3 tons plus cotton compost 1 ton.
Guntur ..	.. Maize and *Variga*.	1. Kossier phosphate 224 lb. plus bonemeal 224 lb. plus cattle manure 3 tons. 2. Cowpea ploughed *in situ* plus super 56 lb.
Nanjanad ..	.. *Samai* ..	Nanjanad Farm Mixture.
Nandyal ..	.. Groundnut ..	Cattle manure 3 tons.
Guntur ..	.. Tobacco and Chillies.	Ammonium sulphate 224 lb. plus potassium sulphate 100 lb. plus super 224 lb. plus cattle manure 2 tons.
Taliparamba	.. Pepper ..	Leaf mould 20 lb. plus fish guano ¼ lb. plus sodium nitrate or ammonium sulphate ¼ lb. plus potassium sulphate ¼ lb. super ¼ lb. plus lime ¼ lb. per vine.
Kasargod and Pillicode.	Coconut ..	Ammonium sulphate 3 lb. plus ashes 20 lb. plus cattle manure 100 lb. per tree.
Nanjanad ..	.. Potato ..	Farm mixture: groundnut cake 500 lb. plus ammonium sulphate 200 lb. plus steamed bonemeal 350 lb. plus potassium sulphate 224 lb. plus concentrated super 336 lb.

Statement showing manurial compositions of some of the important green manures and green leaves.

Materials.	Manurial composition. as per centages on air-dry basis.		
	N.	P_2O_5	K_2O.
Daincha	3·5	0·6	1·2
Sunnhemp	2·3	0·5	1·8
Wild indigo plant	1·8	0·2	0·6
Wild indigo leaves	3·2	0·3	1·3
Indigo refuse..	1·8	0·4	0·3
Boga (*Tephrosia candida*)	2·0	0·7	1·0
Prickly-pear	0·3	1·2	1·1
Rain tree leaves	3·3	..	..
Forest leaves..	1·2	0·6	0·4
Tea prunings..	2·4	0·5	1·3
Green weeds	0·8	0·3	0·2
Sea weeds	1·1	0·3	3·0
Fern weeds	3·1	0·5	3·0
Redgram plant	2·8	0·4	2·0
Virali (*Dodonea viriosa*) cuttings	1·8	0·7	1·8
Glyricidia maculata cuttings	2·9	0·5	2·8
Adathoda vasica cuttings	2·5	0·6	2·9
Malaipoovarasu (*Hibiscus tiliaceous*) ..	2·1	0·5	2·1

Statement showing the chemical composition of some of the Common Organic manures.

Manures.	Composition.			
	N. PER CENT.	P_2O_5. PER CENT.	K_2O. PER CENT.	CaO. PER CENT.
Groundnut cake	7·6	1·3	..	..
Castor cake	5·3	1·6	..	..
Pungam cake	4·2	0·9	..	..
Neem cake	4·7	1·9	..	..
Gingelly cake	6·1	2·4	..	..
Safflower cake	5·5	1·0	..	..
Coconut cake	3·5	1·4	..	..
Linseed cake	5·6	1·4	1·3	..
Tobacco seed cake	4·5	1·8	..	..
Kusumba cake	3·2	..	..	..
Pinnai cake	2·7	1·1	..	..
Illupai cake	2·7	0·9	..	..
Leather shavings	8·4	0·1	..	..
Blood meal	11·5	1·2	..	..
Hoof meal	12·8	..	..	..
Crab manure	1·6	2·8	0·6	34·0
Fish guano and fish manure	6·8	7·1	..	..
Horn meal	14·0	..	..	..
Bone fluff	12·4	5·1	..	6·2
Bone sinews	8·6	10·3	..	..
Bone jelly	6·0	17·0	..	17·8
Bone guano	5·6	21·4	..	..
Bone dust	3·7	24·5	..	31·3
Steamed bone meal	4·4	23·6	..	41·8
Bone char	1·0	29·9	..	38·3
Bone ash	..	38·3	..	..

Statement showing the manurial composition of a number of Chemical fertilizers.

Fertilizers.	*Percentage composition.*			
	N.	P_2O_5.	K_2O.	*CaO.*
Nitrogenous—				
Ammonium sulphate	20·6	..	..	..
Ammonium nitrate	33·0	..	..	..
Sodium nitrate	15·5	..	..	..
Ammonium phosphate (ammophos B).	16·0	21·0	..	..
Diammo-phos	21·0	53·3	..	..
Leuno-phos	21·0	20·0	..	..
Nici-phos	17·5	18·0	..	..
Nitrolim	16·0	..	..	..
Calcium nitrate	15·5	..	..	24·5
Potassium nitrate—crude ..	4·5	..	14·5	..
Potassium nitrate—refined ..	10·5	..	37·0	..
Urea	46·0	..	..	..
Phosphatic—				
Super phosphate—ordinary ..	..	16 to 20	..	..
Super phosphate—concentrated ..	..	43·0	..	..
Basic bone super phosphate ..	2·5	15·4	..	..
Bone black or bone char	..	16·4	..	..
Potassium phosphate	..	23·0	17·0	..
Trichy phosphate	..	22·0	..	54·0
Flour phosphate	..	23·0	..	50·0
Kosier phosphate	..	32·5	..	14·0
Basic mineral phosphate	..	33·0	..	..
Basic slag	..	17·2	..	45·0
Potassic—				
Potassium sulphate	..	..	48·0	..
Potassium chloride	..	..	48 to 62·0	..
Kainit	..	..	12·5	..
Ashes—wood	..	1·5	4·0	22·0
Do. bratties	..	2·0	0·7	..
Do. paddy husk	..	0·5	0·3	..
Do. cotton stalks	..	1·8	9·4	28·6

CHAPTER 19.

AGRONOMY.

Introduction of new crops—Cultural trials—Weed eradication—inter-cultivation—rotational and mixed cropping—Agronomic practices under new irrigation projects—duty of water—irrigation and manuring—Dry farming practices, bunding, scooping, deep and shallow ploughing, spacing and seedrate, interculture, strip cropping, fallowing—Experiments on ryot's lands—Crop improvement, root studies—Dry farming developmental scheme—Contour embankments.

Introduction.—Agronomy is that branch of Agriculture which "deals with the theory and practice of field crop production and soil management." The term embraces all field operations such as preparatory tillage, sowing or transplanting, manuring, irrigation, interculture, harvesting, etc. The various agronomic trials conducted in respect of individual crops in the several Agricultural Research Stations in the State and the results obtained therefrom are dealt with under the respective crops. Such of the agronomic trials which could not be dealt with conveniently under any particular crop or which relate to a number of crops such as mixed crops or crop rotations or trials which relate to particular zones, like the soil conservation problems of the Ceded districts and the irrigation problems of the Tungabhadra Project area are dealt with separately here.

Introduction of new crops or old crops in new areas in Madras.—The introduction and cultivation of new plants in place of old ones is perhaps as old as the history of human civilization. In the early days travellers, explorers and pilgrims collected seeds and plants of useful species they came across in their travels and brought them to their home lands or took them to other countries they visited. The original plant introductions in most countries were thus effected by private enterprise. Though all such introductions have not established themselves in new localities, it is remarkable that several have taken kindly to their new environs. In more recent years the introduction of new plants has become a necessity, in the economy of several countries and some like the United States of America and U.S.S.R. have established special state organizations which send out trained explorers in search of new plants or new varieties of existing species. These are nurtured in suitable localities and are either selected and multiplied or used as basic material for breeding new strains which may prove more economical for cultivation than the existing species. Though such specialized organisations do not exist in India, this country which enjoys a great variety of climate has not lagged behind others either in her contribution to the supply of indigenous plants to foreign countries or in fostering the introduction of useful exotics into her own shores. The various departments of Agriculture in India and enterprising commercial interests have

been alive to the importance of crop introduction. A casual survey of the cultivated crops in India shows that many crops which flourish to-day on the Indian soils had their original homes elsewhere. Outstanding examples of such introductions into Madras are the American cotton (*G. Hirsutum*), African cotton (*G. herbaceum*) groundnuts, Chinese orange, coffee, tobacco, para rubber, potato, sweetpotato, tapioca, cashewnut, papaya, pineapple, grape-vine, tomato, maize, several species of aloes and cactus, deciduous fruits like apples, pears, and peaches, and a great variety of ornamental plants and vegetables. To this list of foreign introductions may be added those which have come from other States in India and the spread of particular crops which were introduced from one part of the State to another either in the original form or as improved strains. The following crop introductions have benefited the Madras cultivator in the recent past.

Cereals.—Rice is the staple food of the State, the crop covering 11 million acres. Rice is almost exclusively indigenous, but examples of some introductions made by the Agricultural Department which have become popular in localised areas are the *puttu* (glutinous) rices of Burma, the *pulavu* varieties from Uttar Pradesh, some flood resistant varieties from Assam and some saline resistant strains from Orissa. Some entirely new areas are now being brought under rice, as in Pattukkottai taluk in Tanjore district which has come under irrigation in recent years, under the Cauvery-Mettur project. In the matter of introduction of new strains, Madras may well be proud of its achievements. About 100 strains released by the Department occupy at present half the area under this crop. Cereals other than rice are also mostly indigenous and consequently the scope for new introduction is very limited. *Whip bajra* (P.T. 700) from Nigeria is almost a solitary exception among the millets grown in the plains. Improved strains of indigenous cereals are however making rapid headway. About 10,000 acres of wheat are grown in the State partly on the plateaux as a cold weather crop and partly on the hills. 3,500 acres of barley are also grown almost exclusively on the Nilgiris.

Pulses.—Most of the pulses raised in Madras are indigenous. Bengalgram (*Circer arietinum*) is the chief introduced crop, grown mainly in the districts of Guntur, Kurnool, Bellary and Anantapur. The acre yield of this crop in the State is however poor; hence the bulk of the consumption is met by imports from the Punjab. A more recent introduction which has taken the imagination of the educated classes, is the soybean. Varieties imported from Burma and Indo-China have done well in certain limited areas but the introduction has not gone beyond the experimental stage. The garden pea is another introduced crop which is severely confined to the hill stations in this State.

Root crops.—The potato is to-day an important crop in the Nilgiri district comprising an area of about 15,000 acres. Among

several varieties introduced from Europe, ' *Great Scot* ' has become the most popular, occupying about 90 per cent of the total acreage. The sweet potato is another example of an exotic which has been well received throughout the State and is raised both under rainfed and irrigated conditions. The tapioca (*cassava*) is another root crop which has come to stay in Madras. Originally introduced in Travancore where it became an important food crop, it has spread to several parts of Madras, particularly Malabar, South Kanara, Tirunelveli, Salem and Chingleput.

Fruits.—Though India is claimed to be the original home of Citrus, it is doubtful whether all the popular varieties of citrus now in India are indigenous. The area in Madras under these fruits is about 46,000 acres comprising mostly of limes (*C. aurantifolia*), loose jacket oranges (*C. reticulata*), the sweet orange (*C. sinensis*) and the sour orange (*C. aurantium*). Smaller areas are under horticultural varieties or hybrids like *Chinee* in Cuddapah, *Batavian* orange in Circars and *Vadlapudi* orange in Krishna. The establishment of the loose-jacket orange which flourishes on the rainy hill slopes of Malabar, Salem, Nilgiris, Visakhapatnam and Godavari districts, is an example of the introduction of a useful plant from one part of the country to another. Deciduous fruits like apples, pears and peaches introduced from Europe have established themselves in limited areas on the hill stations with a sub-tropical climate. The pineapple is another useful fruit plant which has established itself in parts of Malabar, South Kanara, Visakhapatnam and Godavari districts. The papaya is yet another example of a useful exotic which has a cosmopolitan range. The most recent introduction is the tomato which flourishes in a variety of soils and climate and for which the Indian peasant is rapidly cultivating a taste.

Vegetables.—The most important vegetable crop of foreign origin is the *Dhulia* onion (Bellary onion) whose cultivation was almost unknown about 40 years ago. To-day, it is largely grown in several districts. Other introduced vegetables are chiefly cabbage, knol-khol, cauliflower, carrots, beet-root, french-beans, garden-peas, etc., which are raised largely in the hill districts for supply to the towns.

Fodder crops.—Rice and sorghum which are both indigenous, provide the staple fodder, in the form of straw. Fodder sorghum is gaining popularity in some districts where it was not in use before and the *Periamanjal* of Coimbatore is an example of a local variety spreading in the neighbouring districts of Salem and Tiruchirapalli. The chief introductions from outside India are maize, lucerne, Napier-grass, Guinea-grass, berseem, Rhodes-grass and teosinte. These are slowly becoming popular chiefly through the efforts of the Agricultural Department.

Industrial crops.—Cambodia cotton, occupying a normal area of over four lakhs of acres, is an outstanding example of an introduced crop which has benefited the Madras cultivator.

Thanks to the efforts of the Madras Agrictultural Department, the bulk of this area is under improved strains like Co_2, Co_3 and Co_4. In normal years, about 35,000 acres of Uppam (African) cotton are grown. Virginia tobacco which has established itself during the last two decades now occupying over one lakh of acres in the districts of Guntur, Godavari, Krishna and Nellore is another example of a valuable introduction. The strain HS9 is the most popular in Virginia tobacco. Groundnuts with a normal acreage of about 3·7 millions and a money value of over 20 crores of rupees occupies the largest area under any single crop of exotic origin. High yielding departmental strains in this are rapidly becoming popular. That 17 out of 27 districts grow over 50,000 acres of this crop shows its adaptability to different conditions of soil and climate. Another introduction of importance is coffee. Though confined to the hill slopes, the crop covers an area of about 80,000 acres, most of which is *C. arabica*, originally introduced by a pilgrim from Arabia. In the lower altitudes (below 2,000 feet) *C. robusta*, which is less susceptible to diseases and pests is the more popular variety. Most of the tea grown in South India is of Assamese origin. A small amount of chinese hybrids is also grown mixed with the Assam *jat*. This crop which was unknown in the State 50 years ago is now grown over 77,000 acres and forms an important article of commerce. Among the industrial crops of exotic origin, the cashewnut has in recent years taken some importance and it sustains a flourishing industry on the West Coast. Para rubber which is cultivated over 14,000 acres and Cinchona cultivated over 3,000 acres form less important exotics which flourish in restricted localities of the State. The most recent introduction which promises to add to the prosperity of the State is Pyrethrum which yields an important insecticide.

Though sugarcane is indigenous to India and its cultivation was well known in Madras, the popularity of the crop with the ryot made rapid strides only during the last two decades. Till then the varieties most popular with the ryots were introductions from Mauritius, Barbados, Fiji and Java. Seedling canes like Co. 419, evolved at the Sugarcane Research Station, Coimbatore, which yield anything up to 60 tons per acre and can stand short water supply, have along with other reasons, revolutionized the industry in the State, with the result that about 250,000 acres are now under sugarcane. One of the many examples of the new areas coming under sugarcane is Vuyyur in Krishna district where a large acreage has sprung up on what were originally rice lands.

Green manure crops—Daincha (*Sesbania aculeata*) which hails from Bengal is the most important green manure crop introduced in Madras. It is well adapted for rice soils and can stand alkalinity. Of late, *S. speciosa*, which is more succulent and leafy than Daincha is also becoming popular. The seed supply is maintained largely through the efforts of the Madras Agricultural Department.

Miscellaneous.—Among miscellaneous introductions, mention may be made of the prickly pear which till recently was a very important fencing plant. The tendency of the plant to over run arable land, necessitated its destruction by the introduction of the Cochineal insect. It place is now largely taken by Aloes of various types and *Kiluvai* (*Commiphora Berry*). The latter s indigenous to South India, but its use as a hedge plant is being popularized in tracts where it was not known before. The wattle introduced in the Nilgiri Hills, for its bark used in tanning, has come to stay. The mulberry introduced in Kollegal is supporting a thriving silk worm rearing cottage industry.

Among exotic trees cultivated successfully in Madras, special mention may be made of three.—(1) the Casuarina (*Casuarina equisetifolia*) (2) the blue gum (*Eucalyptus globulus*) and (3) the silver oak (*Grevilela robusta*), all of which are of Australian origin. Casuarina is grown on a plantation scale largely on the sandy waste lands along the eastern sea coast of the State, and is the chief source of firewood for the city of Madras and several coastal towns. The blue gum has acclimatised itself successfully on the Nilgiris. Besides yielding the valuable Eucalyptus oil, it is the most important source of fuel in the hill stations of the district. The silver oak is yet another introduction which has taken kindly to the hilly districts of South India. By virtue of its quick growth and straight hardy trunk, it is in favour in the tea plantations to serve as wind-break belts and in some of the coffee plantations for the much-needed shade.

Cultural trials.—Cultivation is the most widely practised agricultural art; but perhaps it is the least understood branch of agricultural science. Discussing the effect of cultivation on increasing crop yields in the Journal of Agricultural Science, E. W. Russel and B. A. Keen have shown that the yield of field crop is, in general, either unaffected or actually reduced by extra cultivation operations. They draw a distinction between cultivation operations which are absolutely necessary such as preparing a seed bed and those that are considered desirable but not absolutely essential. The latter are spare time operations of the cultivator.

The numerous tillage implements and the various cultivation practices that exist today have been mostly evolved through generations of farmers by trial and error methods. These have for a long time been taken for granted even by the agricultural scientists without question, so that, compared to other branches of agricultural science, data on effects of different methods of tillage are meagre today. There are still many agriculturists who feel that the deeper and more thorough the tillage, the greater is the benefit derived from the soil. But the trend of the results in modern scientific experiments however shows that the benefits of cultivation have in general been over emphasised. Allan in 1935 reviewed the results of experiments on primary tillage made in several parts of India and concluded that the inversion plough had no marked

advantage over a good type of paring plough or over the country plough except in the matter of eradicating perennial weeds or in the preparation of the soil for garden crops.

Various cultural experiments were conducted at the Agricultural Research Stations in Madras and the results obtained are summarised below.

Preparatory cultivation experiments.—A large number of experiments have been done in recent years at the Agricultural Research Stations at Coimbatore, Koilpatti, Nandyal, Guntur and Hagari, with the object of determining the optimum preparatory cultivation that is conducive to the economical production of crops. Light iron ploughs drawn by one pair of working bullocks, and capable of turning the soil to four to five inches, local wooden ploughs, big iron ploughs drawn by two or three pairs of bullocks and turning the soil to eight to nine inches, and blade harrows called *guntakas* that scrape the surface soil were used. Plots that were not cultivated in any manner for sowing the crops were also included. The number of times the various implements or the combination of implements were used, ranged from one to eight.

The results of the several experiments conducted at Coimbatore, Koilpatti, Nandyal and Hagari were not conclusive. No treatment was particularly effective year after year, or for a few seasons at least. The general indication was that there was not much difference between one method of preparing the land and another and the final yields obtained were on par with each other. Neither the superiority of any implement nor the efficiency of operating it a number of times was brought out by the experiments. Even the plot that was worked with ploughs or other implements a number of times was only equal to the plot that was not ploughed. The larger number of cultivations and the greater depth of penetration of the implements into the soil were superfluities and were unnecessary in tracts like those listed, where rainfall is not abundant. But it must be pointed out that preparing the land by ploughing or some other operation is necessary to produce a condition of soil that facilitates sowing on receipt of rains and the germination of the seeds sown. Another factor that would determine the number of the ploughings is the rainfall during the fallow period and the presence of weeds in the field. The field has to be cleared of weeds, before they set seed.

It has been observed at the Cotton Breeding Station at Coimbatore that the soil in plots receiving both greater depth and frequent cultivation was generally of a loose texture and unfit as seed bed for drill sowing and suffered by poor germination of seed, sparse stand and stunted growth. During years of heavy rain at sowing period, the uncultivated and the less cultivated plots invariably contained a fair and even stand, without showing any of the defects experienced in well cultivated treatments.

In the absence of special advantages, the method of minimizing cultivation to represent the optimum cultivation would appear to be both practicable and economic.

The preparatory cultivation experiments done at Guntur are in a different category. In all the three years of experimentation maximum cultivation gave the highest yields. The maximum cultivation adopted was ploughing the land four times, working *guntaka* twice and working *gorru* twice, which is the local practice. With an assured and well distributed rainfall occurring in the tract, cultivation benefited both the crops that appeared in the rotation. The cultural practices have, therefore, to be fixed with due regard to seasonal factors and the crops grown.

Korai eradiction.—It was attempted to devise a method of eradicating '*Korai*' (*Cyperus rotundus*) by cultivation methods from the red soil areas at the Central Farm, Coimbatore. The experiment was carried out for five seasons from 1942 and a number of cultivation methods were under test. The results obtained show that working *H. M. Guntaka* or Cooper No. 11 plough once in two weeks and keeping the land fallow without sowing crops for two seasons will reduce *korai* incidence. The land which was cropped in the usual manner and worked with Victory plough once a fortnight during the non-crop period or fallow period had significantly less incidence of *Korai* than the land which was under normal cropping and cultivation. The *korai* incidence was determined by counting the number of live *korai* bulbs in small areas two feet by two feet taken in the plot in question at random, up to a depth of one and a half feet.

Bunding.—The land is divided into small bunded compartments by using the implement called bund-former, during the pre-monsoon period, to facilitate the retention of rain water at the commencement of the monsoon, before sowing and the conservation of soil moisture. Bunding is now a recognized agricultural practice of value in the Hagari tract. Bunding was tried both at Nandyal and Koilpatti and plots bunded were not better than the unbunded plots. While bunding may be of value in regions of low rainfall, it is not helpful in regions where the rainfall is sufficient for normal crop growth.

Transplantation in beds and ridges.—The relative merits of transplanting seedlings on ridges and beds, were studied on *ragi* and onions for a period of four years from 1912–13 to 1916–17 at Hagari. Both the methods were of equal value, but beds required more water for irrigation and consequently the cost of cultivation was higher. Planting onions on ridges was found to be more convenient.

Inter-cultivation trials.—The nature and frequency of after-cultivation necessary for cotton in red and black soils of Coimbatore was studied at the Cotton Breeding Station for three years from 1932. The treatments included shallow inter-cultivation, deep

inter-cultivation, hand hoeing, picking the weeds with hand without using any tools, at varying intervals and also non-removal of weeds by any method. All methods of keeping the land free of weeds inclusive of picking weeds by hand were quite satisfactory, without any method being particularly superior. Inter-cultivation with bullock power seemed unnecessary.

The usual practice in the Hagari tract is to give two inter-cultures for sorghum crop and three for the cotton crop. To test whether by increasing the number of inter-cultures, extra yields could be obtained, an experiment was conducted for four seasons from 1936 to 1940. Two to five inter-cultures for sorghum and three to six inter-cultures for cotton were compared with the two treatments.—(1) Weeding alone and (2) no weeding and no-inter-culture. The results showed that no hard and fast rule could be laid regarding the number of inter-cultures required. The cultivators' practice appeared to be quite sound.

Conclusions.—It is seen from the experiments conducted at several places that yields in dry areas are influenced largely by seasonal conditions and the distribution of rainfall. In years of low rainfall, increased cultivation does not seem to enhance crop yields. On the other hand, if rainfall is well distributed as in the Guntur area increasing the cultivation tends to increase the yields. Experiments conducted at Hagari to test the suitability of deep ploughing for the black soils of the Bellary district indicate that the soils do not require deep ploughing, unless the land gets foul with deep-rooted weeds and that in clean fields deep ploughing is no better than working the *Guntaka* for preparing the land. In the experiments conducted at the Agricultural Research Station, Koilpatti, on the clayey soils, variations in either depth of ploughing, time of ploughing or the kind of implement used did not influence the final yields. In one set of trials in which ploughing was compared with 'no ploughing' during four seasons, the ploughed plots did not yield more than the unploughed plots in any of the years. With regard to inter-culture also, inter-cultivation as a necessary operation for the removal of weeds, is desirable, but it has not been possible to fix definitely the number of inter-cultures to be given to crops, as this is dependent mainly on the prevailing seasonal conditions during the year. As weeding is absolutely necessary for most crops, intercultivation cannot be dispensed with.

Some of the above evidences suggest that it may be possible to dispense with some, if not many, of the age-long cultural habits without adversely affecting the yields. Expenses on cultural operations have risen to very high levels in recent times due to the increased wages paid to agricultural labour and any reduction in the number of ploughings, the depth of ploughing or the number of intercultivation operations necessary for crop production would, therefore, be a definite economic advantage. Research on tillage problems is still in the early stages and from the results so far

obtained, it is not possible in many cases to make definite recommendations that would apply to all soil and climatic conditions. There is thus an immediate need to undertake extensive investigations on tillage practices traditionally followed by the cultivators or actively advocated by the Department to confirm the views held on the subject.

Rotational cropping.—A crop rotation is a sequence of crops grown in recurring succession on the same land. Different crops are grown in a systematic order, one after the other, rather than in a haphazard fashion, or continuous culture of the same crops on the land. Rotations properly framed enable good farming, proper soil management, the observance of soil conservation practices, the proper use of land resulting in maximum returns being obtained.

Appropriate crop rotations are considered desirable from many points of view. The different crops have different feeding habits, they take the moisture and plant nutriments from different soil zones, in varying proportions; they do better when they follow other crops than when they follow the same crops and the object of a suitable rotation is to take advantage of these variations in the habits of plants. Growing suitable crops in the different seasons of the year enables the various operations being distributed throughout the year and aids effective and efficient farm-management. Crop rotations help to reduce losses caused by weeds, insects and plant diseases and to maintain or augument the organic matter and nitrogen content of the soil.

Crop rotations have been in existence in this country for long. They are very numerous and varied, particularly in Madras due to the presence of different types of soil like the black cotton soils, black soils, red soils, alluviums, laterites and so forth and the existence of different systems of cultivation like the dry, wet and garden land systems, with varying combinations of soil types and cultivation practices. Some of the existing rotations have a sound back ground, having been evolved through centuries of experience by a natural method of trial and error.

The value of rotational cropping has been studied at the different Agricultural Research Stations in this State and the conclusions drawn differ, depending upon the joint influence of the soil, climate, season and management. It has to be taken that a rotation found suitable at a particular place need not necessarily be so at other places. The indications obtained by conducting rotation experiments at the various Agricultural Research Stations are reviewed hereunder.

Coimbatore.—Bengalgram, sorghum and cotton are the common crops of the dry lands, grown annually in the above order. The inclusion of a pulse crop like Bengalgram tends to keep up and maintain the yields of the other two crops. Whether cotton follows sorghum or Bengalgram does not appear to affect its yield, but the sorghum crop following Bengalgram appears vigorous and

is benefited. Cotton after cotton continuously is not found to be advantageous.

Tindivanam.—Cereals generally do well after groundnut and better than after cereals. Spreading groundnut following sorghum shows a marked reduction in yield.

Koilpatti.—A study of the effects of sorghum and *bajra* on the following cotton crop showed that there was no difference in the average yields of cotton whether it was grown after *bajra* or *sorghum* in a four-course rotation—*bajra*—cotton—sorghum—cotton and in a two-course rotation where cotton and the cereal were alternated. Cotton following a pulse crop appeared to be the best and the poorest when following a previous cotton crop. The general assumption that, when a crop is grown on the same land year after year its yield tends to be depressed, is not correct under Koilpatti conditions: bajra, sorghum, cotton and pulses were not affected by monoculture over a period of 13 years.

Nandyal.—Sorghum and cotton are commonly grown here alternately. The inclusion of groundnut as a third crop in the rotation was found to be an economic advantage, particularly when it preceded sorghum; the sorghum crop following groundnut gave increased grain and straw yields. Cotton is not affected by the preceding crop, not even by a fallow. Groundnut yield is also not influenced by the preceding crop.

Hagari.—The land was kept fallow, that is without any cropping in the crop season, in alternate years and also once in three years. Sorghum and cotton, the crops included in the rotation, gave increased yields when they followed a 'fallow', but when the total return from one cycle of crops in the rotation was considered, fallowing once in two or three years entailed loss always. Keeping the land fallow for one cropping season is not advisable, though this is a recognized device to get assured crops in the low rainfall regions of America.

Notwithstanding the various attempts made at the different Agricultural Research Stations in the Madras State, it may be stated that suitable rotations have not been evolved, as the differences between the various rotations in their ultimate effect on total return from land has been little or negligible. The introduction of a leguminous crop in the rotation improves the yield of the crop following. The legumes fix atmospheric nitrogen in the plant tissues and leave behind in the soil roots and stubbles which add to the stock of soil nitrogen. Among the leguminous crops, groundnut appears to be popular with the cultivators on account of the high prices that the pods have been fetching in recent years. It takes rank as a commercial crop and its cosmopolitan habits and adaptability to all classes of soils have assured it a favourite place in South Indian agriculture.

Mixed cropping.—In mixed cropping, two or more crops are grown together on the same land in a mixed fashion. This is practised in various ways, with annual field crops, perennial

fruit trees, flower plants and plantation crops. The most common method is the one in which the seeds of the different crops are mixed together and sown broadcast. Where drill sowing is common, the different crops are sown in different lines. The system of mixed cropping in which the different crops are sown at different times also exists in some of the districts. Mixed cropping is more commonly adopted in dry lands which depend upon rainfall only for supplying moisture to the soil and the chief crops grown are millets, oilseeds, pulses, and fibre crops. The cereals are grown mixed with many other crops, whose produce are of everyday use to the cultivator. There was greater emphasis on this aspect in the earlier years, when communications were not properly developed and when people had to depend upon local produce for most of their requirements. Though the need for this type of subsistence farming is past, mixed cropping persists in this land of uncertain rainfall, as even under the worst conditions, one crop or another gives some return and mixed cropping is an insurance against complete failure of crops in adverse seasons. The nature and number of crops mixed differ in the different areas. Almost all the pulse crops except bengalgram are grown with sorghum and *bajra*. The following are some of the common mixtures :—(1) Redgram, blackgram, greengram, gingelly, castor, gogu and cotton. The seeds of the different crops are generally mixed together and drilled or broadcasted. (2) On alluvial soils, cotton is commonly mixed with redgram, maize or sorghum. (3) *Bajra* is grown mixed with redgram in different lines. (4) In the coastal districts of North Madras, where rainfall is not a limiting factor, a large number of crops with a wide range of habits and duration such as rice, sorghum, redgram, ragi, gingelly, cotton, etc., are all sown at the same time, but harvested serially as each crop matures.

Why certain crops are mixed in particular areas in definite proportions and what definite advantages are there, could not be clearly explained in all cases. Some of the advantages attributed to the practice of mixed cropping are economics in cultivation and land, provision for the various domestic needs of the cultivator, an insurance against uncertain weather, pests and diseases and complete failure of crops and maintenance of soil fertility. Mixed cropping trials have been made in various centres with the starting of many Agricultural Research Stations in the State, but not pursued long enough to warrant definite conclusions being drawn. A summary of the trials made are given below and this may help in chalking out future work :—

Coimbatore.—An attempt was made to grow ragi mixed with Cambodia cotton and this was given up as not being remunerative. Mixing pulses with both irrigated and dry sorghums depressed the straw yield and was not beneficial. Cotton was grown mixed with setaria, coriander and horsegram and setaria cotton mixture appeared the most suitable. In one set of trials

blackgram and horsegram sown mixed with cotton gave higher monetary returns than pure crops.

Palur.—Ragi is planted in January and groundnut seeds are dibbled in the standing *ragi* crop in March in this tract. Various mixtures using *ragi,* cotton and groundnut in different combinations and sequences were tried and noted to be not as good as *ragi* (January) plus groundnut (March) mixture. In another trial, cotton (January) plus groundnut (March) gave the best monetary returns, but the trial was confined to one year only and could not be continued.

Tindivanam.—Castor, redgram, sorghum, cotton, setaria and bajra were grown separately and also mixed with groundnut, with a pure crop of groundnut by their side. Mixing other crops induced lankiness in groundnut and depressed its yields, but gave larger monetary returns. Cotton, sorghum, castor and redgram were more suitable than others for mixing with groundnut.

Koilpatti.—Short duration crops like blackgram, coriander and *omum* were grown mixed with cotton, in the same row as also between the cotton rows. There were not significant differences in the yields of cotton under the several treatments.

Sorghum has been known all over the world to depress the yield of the crop that follows it. This is referred to as 'sorghum-injury' or 'sorghum-effect'. The other crop that also preceds cotton in the Koilpatti tract is bajra and it does not leave behind similar after-effects. Various pulses and legumes were attempted to be grown mixed with sorghum with the object of obliterating the sorghum-effect. It has been shown now that if 12 lb. of indigo seeds per acre are sown mixed with sorghum, the indigo plants that came up remain stunted till sorghum is harvested in February, and pull up thereafter. If indigo is ploughed into the soil in August, the succeeding crop is not depressed or affected by the previous sorghum crop.

Guntur.—In a three-year trial where cotton was grown mixed with groundnut, *setaria* and rice, the mixture gave a greater monetary return than pure cotton, and cotton-groundnut mixture was the most paying. Later the common mixtures of the locality, i.e., groundnut-redgram, groundnut-bajra, sorghum-redgram and *bajra*-redgram and pure crops of groundnut, bajra and sorghum were compared. During the first two years, the cereal yields remained at the same level whether grown in a pure state or in the mixtures and the yield of the associated pulse in the case of mixtures was an addition to the ryot. While in the case of the groundnut mixtures, the association of another crop pulled down the yield of the groundnut, when compared with the yield of the pure groundnut crop, during subsequent years, the results were not so clearly defined and in one of the years, the combination of groundnut with redgram gave the maximum money returns.

When chillies were grown pure and mixed with cotton, the mixture was the more advantageous, particularly in years when

chillies were affected by thrips and leaf curl disease was induced in them. Mixing bengalgram with tobacco induced incidence of gram pests on the tobacco crop also and the tabacco yields were affected considerably.

Hagari.—Setaria and cotton are usually drilled alternatively with one row of cotton and two of setaria. A pure cotton crop gives as much in money returns as a mixture of cotton-setaria but cotton-setaria mixture helps to reduce erosion in years of heavy rainfall. The American system advocates these mixed crops being grown in alternate strips as an erosion control measure. Alternating strips of 12 setaria rows and six cotton rows or of six setaria rows and three cotton rows did not appear to be so advantageous as two setaria rows and one cotton row alternating. In adverse years when the setaria crop fails, the cotton rows make good growth by utilizing the intervening space. This advantage is denied to the crops sown in strips.

The performances of mixed crops at the various Agricultural Research Stations have been briefly reviewed. Studies have not been made long enough to provide authoritative guidance but some indications or trends have been noted. In the case of mixed cropping in vogue a long duration and a short duration crop are associated to obtain the best from an uncertain rainfall. In years of low rainfall a small return is had from the short duration crops. In years of well-distributed rainfall, the long duration crop gives a good return. Thus the system of mixing crops enables the cultivator to make the best use of an uncertain season, which could not be predicted at the time of sowing. Inclusion of a pulse crop in the mixture enables the soil nitrogen being maintained without resorting to manuring and this is of value in dry districts where the returns from crops are low and reduction of expenditure in cultivation is all important. Lastly when pests and diseases appear, the entire crop is not spoilt as would be the case if pure crops are raised, as all the crops in the mixture are not subject to attack by the same pests and diseases. Risks of loss of crop are thus minimized.

Agronomic problems of the Thungabhadra Irrigation Project.—In the chapters on "Soils and soil studies" and on 'Irrigation' mention has already been made of the fundamental work on the black soil as a preliminary to the inauguration of the Tungabhadra Project. Laboratory examination of soil samples from the project area and the experiments conducted at the Agricultural Research Station, Siruguppa, had proved that the black soil was irrigable, and that there was no fear of the rise of soluble salts with the advent of irrigation. In this chapter, the agronomic practices that were experimented at Siruguppa, are given below. With a change-over from dry land to irrigation-agriculture, the results of these agronomic trials will be useful and valuable guidance for the ryots of the project area.

Agronomic studies.—The main lines of investigation made under this item were (*a*) studies on the effect of mere irrigation

and time of sowing, (*b*) manurial trials, (*c*) trial of crops and varieties suitable for the black soils under irrigation and (*d*) studies on the duty of water.

Studies of the effect of irrigation only.—The rainfed crops are not normally manured. The common crops, sorghum, *setaria*, and cotton, were raised under irrigation accordingly without manuring. Yields improved slightly but the increase was not appreciable. Irrigation alone did not help.

Studies of the effect of time of sowing.—Crops were raised under irrigation without manuring, as before. The sowings were, however, done at different times. The effects of early sowing were clearly brought out, and the crops sown early did well and gave increased yields. This point was specially emphasized by the behaviour of four varieties of cotton in another series that were manured with groundnut cake and ammonium phosphate to supply nitrogen and phosphoric acid. Extremely high yields were obtained with August sowings. September sowings were badly affected by jassids and very low yields were obtained. That the time of sowing has a profound influence on the yield of crops was clearly brought out in these series of trials.

Manurial trials.—Manures were applied to supply graded doses of nitrogen and phosphoric acid in several combinations to both irrigated sorghum and cotton. The manured plots gave high yields, increasing with the quantities of manures applied; the increases were steep and marked up to 80 lb. of nitrogen and 40 lb. of phosphoric acid per acre. Economic increases of the yield of the tract was shown to be feasible by resorting to manuring combined with irrigation.

Trial of the suitability of crops.—The crops grown in the tract as well as others grown in South India were tried under irrigation. It was seen that a variety of crops could be profitably grown in the project area. Sorghum, setaria, groundnut, maize, ragi, and chillies came up well in the *mungari* season and cotton, wheat, maize and chillies in the *hingari* season. They were all suitable for the tract.

Studies on the duty of water.—The duty of water is taken to represent the number of acres of a crop that could be successfully raised with a constant flow of water of one cubic foot per second, flowing right through the period from sowing to harvest. The duty of water worked out for the project area for the various crops is given below :—

Name of crop.	Average of duty for five years, inclusive of rainfall.	
Mungári sorghum	163	Dry crops—Mean duty—175.
Hingári cotton	265	
Ragi	163	
Wheat	234	
Setaria	103	
Groundnut	156	
Rice	60	Wet land crops—Mean duty—75.
Sugarcane	90	

Period of water-supply.—Sri Thirumalai Iyengar, M.S. (1942) in his report on the Thungabhadra Project low-level canal scheme, has estimated the supply of water available for irrigation, including evaporation losses as follows :—

Months.		Flow (cusecs).	Losses. C. FT.
June—October ..	..	1,800	18,663
October—February	..	1,800	18,663
February—June ..	..	600	6,221
Total	..	4,200	43,547

Nearly the same figures have been adopted by Sri Raghavan (1947) in his report on the levy of compulsory water rates. On the assumption that water received from rains would supplement the requirements of the crops either for earlier cultural operations or for the completion of growth and the maturity of the crop, they have suggested supply of water to land for four months only, first to one batch of lands from June to September and then to another and different batch of lands from October to January to represent the *mungari* and *hingari* seasons, respectively. The area estimated to be brought under irrigation is, therefore, considerable.

Since the tract is subject to frequent failure of rains, the idea of subjecting crops to depend on uncertain rains during one stage of their growth does not fit in logically with a scheme designed for the successful and assured production of crops in a tract noted for recurring and periodic famines. As assured supply of water right from the beginning to the final stages of crop growth would appear to be essential, restricting water-supply to four months is beset with serious difficulties, which could be overcome only by extending it to eight months in the year.

It has been contemplated that water should be supplied to the *mungari* crops from June to September end. When water is let into the channel it will take more than a fortnight for the water to reach the tail end. Experience has shown that cultivators start preparatory cultivation of land only after receipt of water. The sowings will, therefore, naturally extend up to the middle of July and the crops will be harvested up to the end of October and irrigation has to be provided till then for the *mungari* crops.

Regarding *hingari* seasons, water is programmed to be let in from October. Trials have shown that cotton sown in August and September give remunerative yields, while October sowings fail miserably. Water should, therefore, be made available from August onwards for the *hingari* crops, when crops like cotton, chillies, setaria-cotton mixture could be profitably cultivated.

If water-supply is made available for eight months from June, a variety of cropping would be possible and there would be considerable freedom for the cultivator in the choice of crops and the

time of sowing and these will be adjusted to his economic status. The tract has a thin population. The economic condition of the ryot is low, and the labour and livestock are in short supply. It is problematical whether under these conditions the three lakhs of acres proposed could be brought under irrigation farming. On the other hand, if the water is supplied for eight months, and the area commanded is reduced proportionately, there may be a greater chance of reaching the revised target for irrigation farming developing in this tract.

Dry farming.—Dry farming is the system of cultivation in which crops are grown purely under rainfed conditions and is widely practised in large areas of the Madras State, especially in the Ceded districts. The average annual rainfall in the Bellary district is about 20 inches. More than half of this is received within a limited period of four to six weeks between September and October. The two main *hingari* crops, cotton and sorghum, have to depend for their growth on the moisture that is stored in the soil at or about the sowing time which is usually September for cotton and October for sorghum. Rainfall during their period of growth is poor and uncertain. The effective rainfall for the growth of these crops is that received in the period August to October, the normal for the three months being 12 inches against an annual normal of 20 inches. The object of all dry-farming practices is, therefore, to conserve as much rainfall as possible and make it available for crop production. The investigations on dry farming in the Madras State were taken up in the year 1931–35 with the assistance of the Imperial (now Indian) Council of Agricultural Research. The work done consisted of two definite schemes representing two phases of the work.

The Madras Dry Farming Scheme (1934–35 to 1942–43).—This is one of a group of Dry Farming schemes in India, sanctioned by the Indian Council of Agricultural Research, the other three stations being at (1) Sholapur and Bijapur in Bombay, (2) Raichur in Hyderabad (Deccan), and (3) Rohtak in Punjab. In Madras the centre of work was at the Agricultural Research Station, Hagari. The scheme was worked along co-ordinated lines for a period of nine years.

The Dry Farming Development Research Scheme, Madras.—This scheme was in operation at Hagari from 1943–44 to 1947–48, for a period of five years. It carried on the developmental aspect of the previous Dry Farming Research at Hagari. The improvements that came out from the first scheme were put to large-scale tests in the cultivators' fields, round about Hagari to test their suitability for adoption by the cultivators. Investigations on Contour Bunding for the protection of the dry lands against soil erosion and conservation of soil moisture were undertaken during this period. At the close of the scheme the final recommendations were discussed with the District Agricultural Officers in charge of the four districts of the Dry Farming area, Bellary,

Anantapur, Cuddapah and Kurnool with regard to their adoption in the districts.

DRY FARMING TRIALS (THE MADRAS DRY FARMING SCHEME. 1934–43).

Agronomical.

Introduction.—In the tract represented by the Agricultural Research Station, Hagari, the soil is of the type known as black-cotton soil, black in colour and variable in depth from one to ten feet in different localities. During the dry weather, the soil shrinks and becomes very hard on drying and deep extensive cracks are formed, going down to a depth of 3 feet and even more. These soils do not absorb rain-water freely and consequently much of the rain water is lost as run-off. However, the soils are able to retain the absorbed moisture for long periods. On this station, the soil varies in depth from 3 to 4 feet. The chief crops grown in the tract are: (1) setaria (*kharif* crop) and (2) cotton and sorghum (*rabi* crops).

The annual rainfall of the tract is low and precarious; the average annual rainfall for the past 32 years is only 20 inches. Within the last 32 years there were twelve years when the rainfall was below 17 inches, which is generally the minimum required for crop production and crop failures have been occurring approximately once in three years. In the period of nine years from 1934–35 during which the Dry Farming scheme was being worked at Hagari, the rainfall ranged from 12 to 24 inches and in four years the rainfall was 16 inches and below. The worst year was 1942–43, when the rainfall was only 12 inches and crops could not be sown at all. Even this meagre average annual rainfall of 20 inches is very often ill-distributed. The year's rainfall can be divided into three main periods as below :—

Hot weather rains (February 1 to June 6).—The average rainfall received during this period is 4 inches. This is received mostly during late summer accompanied by thunder storms. This rain, although it makes up nearly one-fifth of the total annual rainfall, is of very little use agronomically as the moisture the soil gets from these rains is lost by evaporation by the time the main sowing rains are received.

South-west monsoon (June 7 to September 26).—These four months, when south-west monsoon is active, form the period when the major portion of the rainfall for the year is received in this tract. The average of 32 years for this period is 10 inches. The month of September is the wettest, receiving about 5 inches of rain. As a rule it is on the rains that fall during this period that the success of the cropping of the tract mostly depends. If good rains are received in June itself groundnut is sown. In the period June–July, setaria is sown. If, however, sufficient sowing rains are received only in July-August, setaria is sown mixed with cotton. Cotton is sown in September and sorghum in October.

North-east monsoon (September 27 to January 31).—The period of the north-east monsoon receives an average rainfall of 6 inches. Of this, the month of October receives nearly 3 inches and the rest is spread over the other months. These rains are also highly variable. In the case of both cotton and sorghum, good yields can be obtained if adequate rains are received from July till the middle of October. Not only the total rainfall received during the year but also its proper distribution within the season is very essential for raising crops successfully in this tract. The rainfall of the tract is limited in amount and very often unfavourable in distribution. Owing to the heavy nature of the soil, rain water soaks in only slowly and since most of the rainfall is received in the form of heavy downpours during short periods between September and October, a large part of this rain water goes to waste as run off carrying with it large amounts of fertile surface soil. Thus, sheet erosion is a very widespread and constant feature of the tract after heavy rains. Frequent crop failures are the result of all these adverse conditions. Agronomic research was started in 1934 at Hagari with a view to study the causes of such crop failures and as far as possible to mitigate the severity of the famine by devising suitable agronomic methods.

The economic condition of the cultivator of this tract is very low. The lands are fairly rich but owing to poor rainfall the crop yields are poor and the profits obtained by cultivating them are also low. The chief food crops grown are setaria and sorghum. Cotton is the money crop. The average acre yields of these crops are 300 lb. of grain in setaria, 350 lb. in sorghum and 250 lb. in seed cotton. These yields are practically the lowest in the State. After deducting cost of cultivation, the farmer has in normal years a margin of profit of about ten rupees per acre of food crops and rupees fifteen per acre of cotton. The land values are less than Rs. 100 per acre and land assessment varies from As. 8 to Re. 1 per acre. With these low values as the economic backing of the cultivator, it is seen that he is not able to adopt any improvements which are costly. Therefore it was the chief aim of agronomic research work at this station to try and evolve only such improved agricultural practices as would be within the means of the average cultivator. The agronomic problems tackled during the period of this scheme are dealt with below :—

Bunding experiment.—The moisture required by crops is derived from the soil and in the case of dry land crops, this moisture is obtained only from the rains received. Therefore, all the agricultural operations that help in the greater conservation of moisture in the soil would tend to increase crop yields. Amongst the various methods tried on the station to conserve soil moisture, bunding was found to be the cheapest and most effective. The bunds were about 7 inches high and were formed by an implement known as the 'bund-former'. This implement requires a pair of animals for traction and bunds and cross bunds

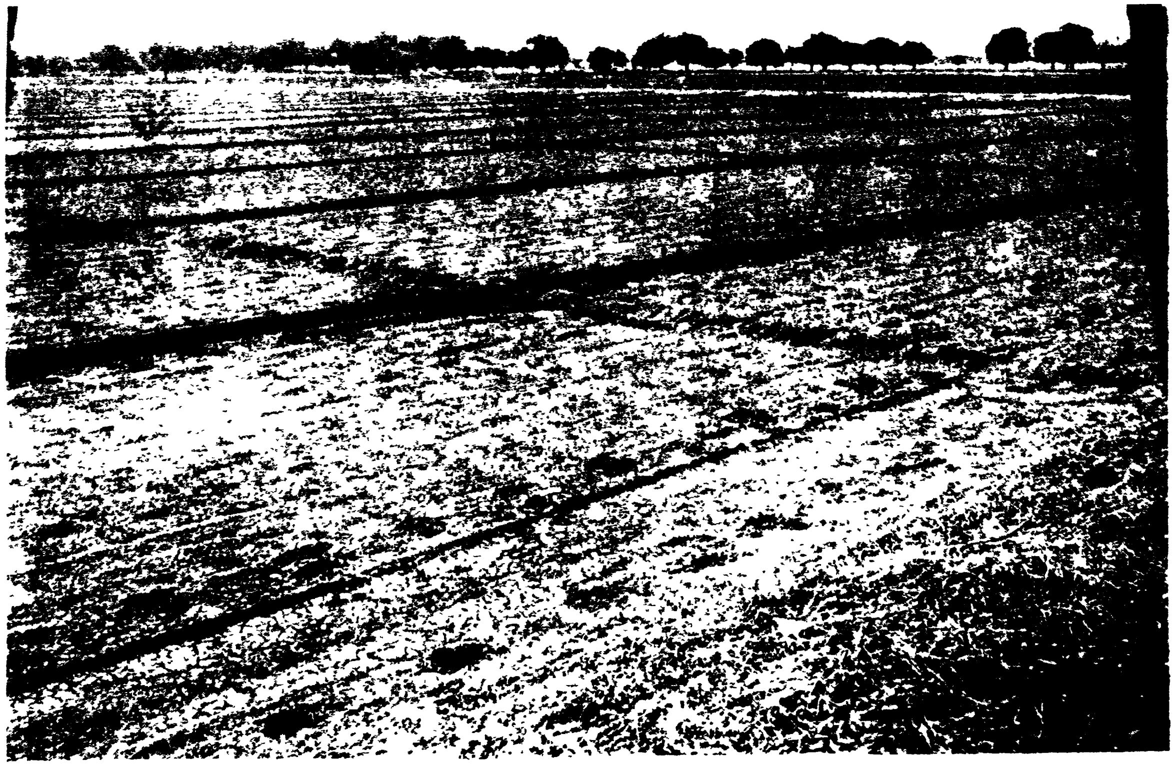


Plate 106.—*A field worked by bund-former showing bunded compartments to hold rain water.* P. 857

Plate **107**.—*Field showing dammed furrows formed by Basin Lister.*

P. 858

can be formed dividing the field into a number of small bunded compartments. With the help of this implement 8 to 10 acres can be covered in a day. Including the labour required for closing the-gaps at the junctions of the bunds, the cost of bunding came to 4 to 4½ annas per acre, and did not exceed 6 annas even in years of heavy showers when the bunds got breached occasionally and had to be repaired from time to time. (Plate 106.)

In the years when the rainfall was below the minimum necessary for crop production, as well as in years of high rainfall with a good distribution, the bunded plots did not show any definite superiority over the unbunded plots. It was in the years when the rainfall was normal or deficient but not below the minimum level required for crop production, that the bunds conferred the greatest benefit. When the yields of the bunded and unbunded plots over the whole period of eight years are taken into consideration, it is seen that on the average the bunded compartments gave Rs. 3-12-0 more net profit per acre per annum than the unbunded plots. From the results of these experiments, it can be stated that bunding the fields in the black soils of this tract is definitely advantageous.

Amongst the four sizes of bunds tried, namely, 5 inches, 7 inches, 12 inches and 18 inches high bunds, the 18 inches high bunds gave the highest gross income. The 5 inches and 7 inches high bunds were formed with bund-formers and the 12 inches and 18 inches high bunds were made with the relatively more costly manual labour. When the cost of treatment in each case was deducted from the gross income, the 7 inches high bunds gave the maximum net income. Hence this size is being recommended for adoption, on fairly level fields. With this size of the bunds, the most convenient size of the individual bunded compartment was found to be 100 links square, or 10 cents in area. In lands that slope to some extent the area of the bunded compartments can be reduced to 5 cents.

Scooping trials.—Scoops are small shallow depressed pockets formed in the field on the surface, by working the implement, Basin Lister. (Plate 107.) A number of iron prongs, shaped like plough bodies more or less, are assembled on a rigid frame mounted on wheels. When the implement works, the prongs are alternately lifted and depressed by a cam arrangement. When the prongs are lifted, they do not make any marks on the soil and when depressed, furrows are formed, which get closed at the ends when the prongs are lifted. Thus a series of small pockets are formed along the course of the implement, which are only furrows broken by undisturbed soil along the course of the furrow. It is more costly to scoop the land than merely to bund it. For soils round about Hagari, which are fairly level, bunding alone was quite as good as scooping for conserving rain water and scooping

in addition was found unnecessary. Scooping would, however, be advantageous, where the land is sloping.

Ploughing and bunding experiments.—In the soil moisture experiments which were in progress on the station for eight years from 1927 to 1934, it was found that the bunding and ploughing at intervals were beneficial to crops. Trials were made from 1936–37 to 1940–41 to assess the benefits of ploughing coupled with bunding. As ploughing is a costly operation, it was done once in two or four years. Though the ploughed and bunded plots were superior to the rest in certain trials, the net income derived after deducting the cost of the preparatory cultivation was nearly equal in all cases. There seems to be no need to deep plough the black soils unless they become foul with deep-rooted weeds.

Trial of ploughing with a light iron plough.—As the cost of deep ploughing these black soils is very high, experiments were conducted from 1939–40 to 1941–42, to see if light ploughing every year or alternate year with a plough requiring only a single pair of animals would be beneficial for these soils. There were two sets each year, one under cotton and the other under sorghum. The experiment was in progress for three years. When the three years' data were taken together, there were not significant differences between the treatments either with cotton or with sorghum, indicating that light ploughing has no beneficial effects on black soils of medium depth (3 to 4 feet deep) in this tract.

Spacing experiments with sorghum and cotton.—In this tract sorghum, and cotton crops are sown with the same drill, having tynes 13½ inches apart. Sorghum is sown in all the rows whereas cotton is sown only in the alternate rows, with a spacing of 13½ inches for sorghum and 27 inches for cotton. Experiments conducted with different spacings showed 18 inches spacing to be the optimum for sorghum and 36 inches for cotton. As sorghum and cotton can be sown at the optimum spacing with the same 18 inches drill, these spacings are being advocated to the cultivators for general adoption.

Interculture experiments on sorghum and cotton.—The number of intercultures usually given to sorghum and cotton in this tract are two and three respectively. Experiments were conducted from 1936–37 to 1939–40 to see if these could be varied with benefit to the crops. Two to five inter cultures for sorghum and three to six intercultures for cotton were tried and these were compared with 'weeding alone (hand weeding)' and 'no intercultures and no weeding' as the control. When the four years' data were analysed it was found that (1) when the dry weather set in early, larger number of intercultures were beneficial, but when wet weather continued for a longer period, it did not result in greater benefit; (2) weeding by itself was as good as intercultivation; (3) on the average no interculture and no weeding plots were the poorest owing to the presence of weeds. This was quite

clear in the case of cotton but not so clear in the case of sorghum; (4) the main benefit derived from intercultivation seemed to be the removal of weeds. Hand weeding is costly and the cheapest way of removing weeds is to interculture as often as necessary.

The cultivators' practice of giving two intercultures to sorghum and three to cotton seems to be quite sound. No hard-and-fast rule could be laid with regard to the minimum number of intercultures as it depends upon the seasonal conditions of the year. Keeping the basic number of two intercultures for sorghum and three for cotton, it may be necessary to give one or two more intercultures if the fields should become foul with weeds owing to rains received after sowing.

Strip-cropping experiments—(a) Strip-cropping with setaria and cotton.—If sowing rains are received in August the cultivators in-this tract sow mixtures of setaria and cotton. The usual practice is to sow the two crops in alternate rows or two rows of setaria alternating with one row of cotton. Setaria, being a quick growing crop, utilizes the moisture and nutrients quickly to the detriment of the slow growing cotton. To eliminate this competition the sowing of setaria and cotton in strips in the proportions of 1 : 1, 2 : 1, 6 : 3, 12 : 6 and 3 : 2 were tried. The results were not conclusive.

(b) *Strip-cropping with setaria and groundnut.*—In this tract *kharif* grains are very uncertain and *kharif* crops sown in this season are setaria and groundnut. The former is a short duration crop and the latter is a long duration one. These two crops are usually sown pure in separate fields. In years of poor rainfall groundnut with its long duration suffers more. The two crops were sown in alternating strips in the same field, to get over these disabilities. The strips were found to be only intermediate in money value of produce between pure crops of setaria and groundnut indicating that there was no advantage in sowing the crops in alternating strips instead of as pure crops in separate fields, in the black soil areas of this tract.

Fallowing experiment.—Preliminary experiments conducted on the station for four years from 1934–35 showed that in the year of cropping, plots fallowed in alternate years gave nearly double the yields of plots sown every year with sorghum. As sorghum and cotton are grown in alternate years in this tract, a more elaborate experiment was started in 1936–37 to see whether fallowing once in two or three years would fit into the rotation of this tract. The experiment was in progress for six years. When the economics of the treatment were worked out it was seen that the average value of produce per acre per season from the treatment " Cropped every year " was greater than that from the treatments " fallowed once in two or three years ". Under the existing system of growing sorghum and cotton in this tract in rotation, fallowing is not profitable.

Manurial experiments—Comparison of farm yard manure and compost prepared by the Indore ' rain water method '.—Farm yard manure and compost were compared by applying them to setaria and sorghum on an equal nitrogen basis to supply 50 lb. of nitrogen per acre, over several seasons. The results were not consistent. In general, farm yard manure was found to be more beneficial than compost. The good effects of manuring were felt in years when the rainfall and its distribution were satisfactory. The duration of the residual effects of manures ranged from 3 to 5 years. In years of poor rainfall the residual effects were not felt and the intervention of such years prolonged the duration of the residual effects. With regard to the actual profits obtained by manuring, it mainly depended upon the quantity of manure applied.

Optimum dose of farm yard manure.—Since the quantity of cattle manure available in this tract is limited due to the low cattle population, experiments were undertaken to determine the optimum dose of farm yard manure. A small dose like 3,000 lb. of farm yard manure per acre was ineffective. Doses of 5,000, 7,000 and 9,000 lb. of farm yard manure were equally effective. On the whole it may be said that a net profit of Rs. 2-8-0 per acre (after deducting the cost of manure) would accrue, if the lands are manured at the rate of 6,000 lb. of farm yard manure per acre. The problem of manuring in this tract is mainly a question of its availability. The quantity of manure that is produced is sufficient to manure only a small portion of any holding. Therefore, it cannot be advised that manuring at a particular dose should be adopted for all the lands that a cultivator holds. It is a question of how much land can be manured in a holding with the limited quantity of manure that is produced. A cultivator owning a pair of work animals along with a cow or a she-buffalo will be able to produce yearly cattle manure which will only be sufficient to manure about one acre. As the residual beneficial effects of manure persist for some time depending upon the nature of subsequent seasons, it will not be necessary to manure the same land every year. The cultivator of this tract can therefore be advised to manure his fields at the rate of 5 or 6 cart-loads of cattle manure per acre, once in 3 or 4 years.

Complex experiments with bunding, manuring and fallowing.—In the agronomic experiments, bunding, manuring and fallowing, individually gave increased yields. A complex experiment was started in 1940–41 combining all the improvements. Fallowing proved to be an indefinite treatment and in combination with other treatments, it did not furnish conclusive results.

Large-scale trial at Joladarasi.—Improved dry farming practices evolved from the experiments on the station were put to a field scale trial in 1941–42 in cultivators' fields at Joladarasi, a village 5 miles from the farm. Twenty acres were under

improved methods and five acres under cultivators' methods as control as noted below :—

Experimental Area.

1. Bunding (Seven inches high bunds by the bund former).
2. Spacing for cotton 36 inches.
3. Spacing for sorghum 18 inches.
4. M. 47-3 sorghum strain.
5. Fallow in alternate years in three acres.

Control Area.

1. No bunding.
2. Spacing for cotton 27 inches.
3. Spacing for sorghum 13½ inches.
4. Type T-1 sorghum.
5. No fallow.

Cotton and sorghum were each sown in seven and half acres in the experimental area and in two and half acres in the control area in 1941–42. Due to the failure of rains no crops could be sown in 1942–43. Taking the data gathered in 1941–42, into consideration, it was found that in the case of cotton the extra cost of cultivation per acre due to the adoption of the improvements was Re. 1-0-9. The increased profits per acre owing to the adoption of the improvements was Rs. 5-1-11 over and above the control. In the case of sorghum which was adversely affected during the year, the net profit per acre owing to the improved methods came to Rs. 1-11-3 per acre. These trials indicated that it may be profitable to adopt these improvements in these tracts. Three acres were left fallow in 1941–42 to be sown next year to assess the value of fallowing. But owing to the failure of rains no crops could be sown in 1942–43 and this aspect of the problem could not be pursued.

Crop improvement.—Type 1 strain sorghum has been under distribution since 1918. Six types of sorghum from Bombay kept under observation at the station from 1934–35 were earlier than the local types by about 15 days. They were found to yield some grain even in years of deficient rainfall, when the local types completely failed. Amongst these, strain M47-3 was found to yield the highest average grain yield besides giving fair yields of straw as well. From 1939–40 onwards this strain was issued to the cultivators in large quantities for extending the area under the strain.

The local types of sorghum failed in years of deficient rainfall on account of their long duration. The cultivators did not take kindly to the Bombay strain M 47-3 as its panicles are loose. They prefer compact panicles. The evolution of short duration types, with compact panicles, by hybridization is under way.

Sorghum is sown in October, towards the close of the rainy season and the choice of a variety suitable for the moisture conditions prevailing in the soil is rendered easy. In years of good rainfall, H1 or the local long duration type could be sown and in seasons of low rainfall, M 47-3 the short Bombay type could be sown. Both H1 and M47-3 give nearly the same grain yields in normal years, but H1 with its taller habit gives more straw and the production of sufficient straw is also a consideration with the cultivators of this region. H1 does not set grains in years of low rainfall and gives only straw, while the shorter duration M47-3 successfully produces grain also. Since the seed rate of the crop is low, being only four to six lb. per acre, sufficient seed of both the varieties could be preserved and the appropriate variety chosen for sowing at the time without any difficulty. In Setaria, as a result of pure line work two selections K23 and K68 were evolved. K23 is suitable for a variety of soils ranging from sandy to deep black soils; yields more than 10 per cent over the cultivators' seed, and is earlier by a fortnight. For deeper soils and tracts of higher rainfall K68 is more suitable, being earlier than even K23 by about a week. The area under these strains is being yearly extended by raising seed farms and supplying large quantities of pure seed to the cultivators.

Studies on the root system of crops.—In this tract of low and uncertain rainfall, it is necessary that only such varieties of crops are chosen as are able to utilise the limited moisture supply in the soil to the utmost. Since the root system is all important in absorption of moisture and nutrients from the soils, root studies were made to assess which of the various agronomic operations had the maximum effect on the root development of the different crops raised in the tract.

General differences between the root systems of different crop plants.—The main crops grown here are setaria, sorghum and cotton. The root system of both setaria and sorghum is of the fibrous, adventitious type. The roots in setaria are thinner and finer and are profusely branched. The dry weight of shoots in setaria is greater than that of the roots. The maximum lateral spread and vertical penetration of roots were less in setaria than in sorghum, in consonance with the smaller size of the shoot system of setaria. In cotton, the root system consists of a thick tap root which penetrates almost vertically downwards to nearly 40 inches and give off lateral branches at various levels along its length. The branching and ramifications are less profuse than in setaria or in sorghum.

Differences between varieties of same crop plants—Setaria.—Strain K-23 has been the standard strain of the station since 1935. It is about 100 days in duration and is characterized by profuse tillering, thin clums and numerous compact, pencil-like panicles. K191 was chosen as an entirely dissimilar type, with only one or two tillers, stout clums and large loose panicles to see the differences

between the root systems of two such dissimilar types. K191 does not come up well as a rainfed crop but thrives well under irrigation. The study of the root system revealed that except in the early seedling stage when K191 showed a somewhat quicker root development, K23 was found to be superior in all respects, in the total number and length of roots, the maximum vertical penetration and lateral spread. This difference in root development explains why the strain K23 is able to thrive much better than K191 as a rainfed crop in this semi-arid tract. The latter, on account of a relatively quicker root development in the earlier stages, is better suited for irrigated conditions, where high seed rate is used and an adequate supply of moisture is assured.

Sorghum.—Root studies were made on two local types of sorghum T1 and T12 and six short duration types from the Bombay State. It was observed that the Bombay types put forth a large number of roots in the early stages as compared to the local types. They had also a greater lateral spread and deeper vertical penetration of roots. Owing to this development of a quicker and a more efficient root system, the Bombay types have been able to withstand drought better than the local varieties.

Relative growth rates of shoot and root (Setaria).—From a study of the relative growth rates of root and shoot at different stages in the plants' life it was found that at each stage there is first an elaboration of the root system and only after this absorptive equipment is well secured is there any further elaboration of the shoot system. This alternation of growth in root and shoot seems to indicate a balance in the development of the underground and overground parts, which serves to insure the plant against drought.

The effect of agricultural operations and manuring on root development of crops—Bunding.—The effect of bunding upon the root development of crop has been one of general increase both in lateral spread and in vertical penetration. This improvement was evident both in sorghum and cotton, from the earliest up to the adult stage. In years of poor rainfall, the total root development, both in bunded and non-bunded plots, was less than in good seasons, but the difference in root development between bunded and non-bunded slopes was more marked in seasons of deficient rainfall.

Effect of fallowing.—Both cotton and sorghum have distinctly better root development when grown on land that was left fallow the previous seasons. The increases in soil volume of root spread were also of the same order as the increases observed in the final yields in cotton and in sorghum. Plants in fallowed plots were shorter in the early stages because most of energy seems to be expended in elaborating a root system that was larger than in plants in 'cropped' plots. Later on, after this root system is well established, the shoot also increases in height and ultimately grows taller than the plants in 'cropped' plots.

Effect of manuring.—When applied to setaria on the basis of 50 lb. of nitrogen per acre, both compost and farm yard manure were found to promote a better growth than 'No manure'. Manured plants were also found to utilize the water absorbed more efficiently than plants that received no manure. Between compost and farm yard manure, the latter was slightly superior. Root development was marked with increasing doses of farm yard manure.

Root studies on crop mixtures—Setaria and cotton mixture.—When grown as a mixed crop, the root systems of both cotton and *setaria* feed in the same zones of soil. This results in a severe competition for water and nutrients. In this competition the quicker growing *setaria* depletes the soil moisture to such an extent that the cotton plant almost invariably gets badly stunted in growth unless good rains are received after the harvest of *setaria*. This does not often happen. This competition and stunting effect could be remedied by growing the two crops in alternating strips. *Sorghum* and *bengalgram*. Here, too, root studies disclosed the fact that both the crops feed in the same soil zone. Root competition is naturally very severe between the two crops. Bengalgram being shorter in duration grows more rapidly and depletes the soil moisture so rapidly that the sorghum crop gets badly stunted. The mixture is hence, one that cannot be recommended for general practice. *Setaria and groundnut.*—This is a good combination because groundnut is a shallow feeder, while setaria is able to utilize the moisture from deeper layers of the soil. With this combination, root competition is avoided and both the components of the mixture are able to grow almost as well as if they were pure crops.

Studies on the relative efficiency of crop plants in checking soil erosion.—Soil erosion is a serious problem in the heavy black soils of this tract, and since the main controllable factor in checking erosion is the presence of an adequate plant cover, erosion studies were made at Hagari with the object of determining the relative anti-erosive efficiencies of the crops and crop mixtures commonly grown in this tract. The method consisted in washing a definite volume of undisturbed soil, taken out in a wooden tray under various types of plant cover, with a steady spray of water and noting the time taken to erode the soil completely. The time required to erode bare soil, taken from the same field in one of these wooden frames was taken as unity, for comparison in working out the relative anti-erosive efficiencies of different crops. A wide range of efficiency was observed to exist between the various crops grown in this tract. Cotton afforded very little protection and was hardly better than bare soil. *Setaria* had an anti-erosive ratio of nearly 3 : 0 in the seedling stage which increased to 4 : 1 when the plants were about three months old. Groundnut, especially the spreading variety, was equally efficient, with an anti-erosive ratio of 4 : 6. In crop mixtures, a mixture of setaria and cotton had an anti-erosive value midway between those of the two pure

crops. A mixture of setaria and groundnut had a higher efficiency than the pure crops individually.

Studies in the formation of hard layer in black soils.—As a natural result of loss of moisture from the soil during the dry weather after the close of the north-east monsoon, the heavy black soils of this tract develop a hard impenetrable layer some six to nine inches thick, below the top two to three inches of loose earth. This layer is so hard that it prevents the penetration of roots and strangulates the roots that have already pierced it, and thus affects adversely the growth of the crop. An experiment was laid down in 1939–40 to ascertain how far simple agronomic operations like ploughing and manuring influenced the development of this hard layer. The results seemed to indicate that manuring with farm yard manure at 9,000 lb. per acre, as well as ploughing to a depth of four inches were helpful in delaying by about a fortnight, the full development of the hard layer.

Incidence of earless plants in sorghum.—It is very common in this tract to find fully developed sorghum plants without earheads. Agronomic practices like bunding, scooping, fallowing, etc., which conserve more moisture in the soil tended to reduce the proportion of earless plants.

DRY FARMING DEVELOPMENTAL RESEARCH SCHEME, MADRAS (1943–44 TO 1947–48).

The scheme of the Dry Farming Developmental Research was in operation over a period of five years from 1st July, 1943.

Objects of the scheme.—This scheme was intended to carry on the developmental aspect of the previous Dry Farming Research at Hagari which was in progress from 1934 to 1943. Certain Dry Farming improvements, like bundformer bunding, wide spacing, new drought resistant strains etc., were noted to be beneficial under the controlled conditions and in small plots obtaining in a Government farm. The developmental stage succeeded the research stage in July 1943 and continued for five years in the fields of the cultivators near the Hagari Farm. The object of this work was to try out the improved Dry Farming practices on a large scale on the cultivators fields to give them the opportunity to see for themselves under their own conditions of soil and cultivation, the value of the improved practices. The work was done by the cultivators themselves, by their own cattle in their own fields. No financial help was given to them by Government in the matter of cultivation expenses. Permanent and temporary bunds were put up at Government expense and the improved cultivation as suggested by the scheme staff was undertaken by the cultivators themselves at their own expense. Sowing, weeding, harvests were all done by them. An area of 800 acres was chosen near the farm involving about 25 cultivators. At the end of each year all the cultivators were met at an informal conference by the staff and the results of work in their fields were freely discussed. Thus for five years, intimate relationship was

established between the Departmental staff and the cultivators with a free exchange of views on all items of work, and the considered views of the Research workers on the various improvements were amply corroborated.

Contour embankments.—During this period it was noted that field embankments helped to conserve rainwater and check soil erosion, resulting in increased yields and improvements of the yield. While forming small compartments with bunds made with the bundformer is generally effective for lands with a slope of less than five per cent, it is unsuitable for lands with greater slopes. Contour embankments are effective for slopes greater than five per cent. Levels are taken and points of the same level are connected by embankments 11 feet wide at the bottom, three feet wide at the top and two and half feet high. As large quantities of water collect at the lower end of the fields near the embankments, the bunds are subject to great strain and provision is made for draining the excess water through four to six inch pipes laid through the bund six inches above the level of the land at suitable points. As a further safeguard, cross bunds are also provided to break the continuity of the large stretches of water spread. Laying the embankments strictly on the contour, that is on the points with the same level, tends to cut up the existing holdings into inconvenient bits and the bunds are smoothened so as to conform to the existing boundaries of fields, when they are within a maximum of 100 feet of the contour line already marked. This is offered as a practical solution compromising the theoretical alignment of the bunds with the existing alignment of the land into fields, owned by different people. This may be called the '*Hagari Bunding*'.

The earth required for the formation of the bund is taken from the down stream side of the bund, at least ten feet away from the bund, for giving the necessary stability to the bund. The downstream side is the highest point of the field and water collecting in the burrowed pits easily seep to lower levels and the lands gets dry and ready for cultivation easily. When however the earth is taken from the upstream side, it leads to chronic water stagnation in the pits formed, as it is the lowest point of the field from which water could not move down to any lower level.

These embankments serve to keep the rainwater fallen on the land itself, except when there are heavy downpours in quick succession. The water seeps into the soil in course of time and water is thereby conserved. The erosion of the soil is also prevented as violent and fast movement of sheets of water is effectively prevented by the provision of bunds. In course of time, it may be expected that the soil would be moved from the higher to the lower levels of the field, bringing about at least a slight reduction of the slope.

Extension work.—To empower the Department to take up land improvement work such as contour bunding, contour trench-

Plate 108.—Contour embankment.

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Plate 109.—Contour bund.

ing, gully-plugging, terracing etc., in private lands, Government have already taken necessary legislative measures. The Madras Land Improvement Schemes (Contour Bunding and Contour Trenching) Act 1949 has been passed and this empowers the Agricultural Department to take up land improvement schemes in private lands and recover the entire cost or a portion thereof from the land owners in suitable instalments. Provision is also made in the Act for hearing objections, if any, from the land owners for consideration.

Government have sanctioned the scheme for the Ceded districts and work is started in three centres viz., Hagari, Allur, in Bellary district and Guntakal in Anantapur district.

ELECTRO CULTURE.

Dr. S. S. Nehru, I.C.S., in Manipuri, Uttar Pradesh and Col. Neel, in Peshawar, North West Frontier Province, noted that sparking plants with a car magneto and covering the stems with old iron wire netting induced vigour in plants in a remarkable manner. Sprinkling water sparked with magneto was claimed to rid plants of the insects affecting them. The Cotton Specialist was deputed to Uttar Pradesh to study these electro cultural treatments in 1938. During his study tour, he saw remarkable effects of electro-cultural treatments in certain cases and recommended that the effects of electro-cultural applications on crop plants may be usefully studied at the various Agricultural Stations in the State.

Accordingly experiments were conducted during 1938–39 and 1939–40 for a period of 20 months by several officers of the Department at the various Agricultural Research and Breeding Stations, Anakapalle, Maruteru, Koduru, Hagari, Tindivanam, Palur, Aduthurai, Koilpatti, Coimbatore and Pattambi, with the object of studying the extent of improvement that could be effected on crops, trees, and cattle by means of electro-cultural methods. Rice, *ragi*, sorghum, *bajra*, *setaria*, cotton, groundnut, sugarcane, knol-knol, tomatoes, plantains, acid limes and mangoes were the several crops on which the experiments were conducted. Care was taken in all cases to maintain suitable controls and replications such that the data could be analysed and interpreted statistically. In the case of crops, the treatments consisted of sparking the seed dry, soaking the unsparked seed in sparked water for different periods, soaking sparked seed in sparked water, sparking germinating seeds, spraying sparked water on seedlings and irrigating the plants with sparked water. Observations were made on germinating capacity, height, number of tillers, size of grains and the general appearance of the treated and untreated crops. Finally, their yields were compared. On the whole there were 18 seed treatments on rice, 26 on millets, 16 on cotton and 9 on groundnut in 1938–39. No beneficial effects were observed in general. Only in two cases of rice was there significant improvement in yield and in others the differences were within the limits of normal variation. The effect of irrigation with sparked water was tested on rice,

cotton and millets. Rice was also irrigated with sparked water. In none of these trials, reliable increase in yield was noted. In a small area looping a continuous iron wire around each rice plant and sparking the loops were tried at Maruteru. This would correspond to the jacketing of tree stems with old iron wire netting. There was a distinct increase (five per cent) in the yield of paddy. It should, however, be pointed out that an acre of rice would contain about two lakhs of plants (excluding tillers) and the cost of looping with iron wire would be prohibitive when compared with the value of five per cent increase in the resulting yield. It was, therefore, concluded that electro-cultural treatments would not generally improve the yield of agricultural crops, that the increases sometimes observed would have to be taken as normal variations engendered by the changes in the seasons and soil fertility and not by the treatments. With regard to their effects on trees the results secured at six research stations showed that only in two cases were there definite responses. In some cases stimulation of early growth was reported while in others no difference between the jacketed and unjacketed trees was recorded. Again in one set of *chinee* trees grown at Kodur Farm distinct increase in girth was noticed due to jacketing while in another set, the increase in girth was greater in the unjacketed control. The general trend in most of the experiments was towards the futility of the treatments.

The single experiment that had been carried out on cattle was not encouraging. The trials made by the Government Entomologist, on 20 kinds of insects did not produce useful results. Out of 271 cases of trial, only in nine, the responses were distinctly better than those of the untreated controls. When the experiments were repeated the same result were not obtained. In only four trials out of 210 seed treatments tried, were the responses beneficial. Looping wire round the paddy plant and sparking the iron wire gave consistently better results during two successive seasons. This treatment can, therefore, be taken as one which can be depended on to give increased yields in rice, but not practicable.

The experiments on electro-culture were discontinued in 1940, in view of the fact that none of the treatments produced distinctive improvements in yields of cultivated crops consistently.

During 1949, a Special Officer was appointed for conducting electro-culture experiments. He conducted experiments for a period of six months from February to August 1949 on crops grown at the Rice Research Station, Tirurkuppam and the Government House Vegetable Farm, Mount Road, Madras. The experiments on 'sparking' and 'jacketing', etc., were done on vegetables at Madras and on rice and fruits at Tirurkuppam. There were again no consistent differences between th treated and untreated crops. Electro-culture of crops was, therefore, deemed impracticable, and further trials were not taken up.

CHAPTER 20.

CHEMICAL RESEARCH.

The chemistry of sugarcane—jaggery quality and factors affecting —coconut jaggery improvement in quality—Studies on rice—quality, starch, cooking tests and nutritive value—Studies on potato, food value, deterioration on storage and black heart disease—Tobacco, Jaffna and Indian types, chewing types, factors affecting nicotine content—studies on quality in coffee—Chemical studies on banana, pineapple, sweet potato, beet-root, fodder grasses and coriander—The preservation of ginger and cashewnut—The viability of Kolinji seeds—Improvement of marginal lands—studies on rubber from cryptostegia vine—The proteins of groundnut—The chemistry of fungicides—Laboratory investigations on the preparation of malt and malt products from Indian cereals, infant and invalid foods, beverages—By-products from milk, cheese, casein—Activated carbon from paddy husk, and its use as a clarifying agent—Agar-agar from sea weed—vegetable milk from oil-seeds and pulses.

Plant Physiology.—Vernalisation—Pre-treatment of seeds by soaking in phosphate solutions—Trace elements—Weeds and their control, hormones.

Bacteriology.—Solubilisation of Trichy phosphate—Isolation and study of sulphur oxidising bacteria—Nitrogen fixation by non-symbiotic bacteria—Groundnut nodule organisms—Legume studies—Cross inoculation—Factors governing nodule formation and nitrogen fixation—Photo nitrification—Associated growth of legumes and cereals—Fermentation of molasses to power alcohol—Manuring and micro-biological flora—Examination of soils for algæ and protozoa—Studies on milk bacteriology.

The Agricultural Chemist's section was started in 1906 and in common with similar sections elsewhere, its main function originally was the elucidation of problems on the chemistry of soils, manures, foodstuffs and agricultural products and processes. Some of the major problems studied in the section have been detailed elsewhere in the chapters on " Soils ", " Irrigation " and " Nutrition ". In addition to these major problems, a number of other investigations has been carried out. As some of them have yielded important and valuable results, they are mentioned in this chapter.

Studies on the chemistry of the sugarcane—(a) Top-bottom ratio.—Many items of research in the section have centred round the sugarcane. One of the first problems studied was the chemistry of sugar formation in the crop during growth and to find that stage in its maturity at which it should be harvested to give maximum return to the grower. The sugar content of the crop was determined at various stages. The results indicated that

the cane ripens joint by joint and that at the time of maturity the sugar contents of the top and bottom halves are practically the same. Based on this result a method easy of adoption by the ryot was evolved to judge the maturity of the cane and to harvest it at its maximum content of sucros. This is because after maturity is rached there is reversion of sucrose and keeping the cane longer in the field will yield a diminished return. The method evolved was as follows. A few canes selected at random from the field are cut into exactly two halves at the middle and the juice extracted from the two portions separately. A Brix hydrometer gives the total solids in the juices of the top and bottom halves and from these the top-bottom ratio of the total solids is calculated. In the early months, this ratio will be much smaller than unity and as the cane ripens the ratio will go on approaching unity and after maturity is reached, will start falling again. The nearer, therefore, the top-bottom ratio is to unity, the more mature is the sugarcane. This criterion has been used not only on Government Farms but also by many ryots to judge whether the cane crop is ready for harvest. Recent work in the section has shown that this ratio is not a very reliable standard for purposes of accurate field experiments. A low glucose content and a low nitrogen content of the juice are better criteria for judging the ripeness of the cane. The advantage, however, of the top-bottom ratio is that it can be determined by any ryot equipped with merely a Brix hydrometer. On the other hand, the estimation of glucose and nitrogen in the juice requires laboratory facilities and the services of an analytical chemist.

(*b*) *Arrowing*.—There is a general belief that arrowing (flowering) in sugarcane leads to a deterioration of juice quality. The experiments on this aspect have shown that arrowing is accompanied by an increase in the purity of the juice, but is set back by an increase in crude fibre content and by a decrease in tonnage and extraction percentage. Generally the results have indicated that arrowing is not a serious handicap unless the cane crop is left standing for a long time on the field.

(*c*) *Nitrogen content and jaggery colour*.—Studies on the colour of jaggery obtained from sugarcane included the examination of the juice for the various constituents that might impart colour. It was seen that a juice with a high nitrogen content gives a jaggery of poor colour even when filtered through active carbon. It appeared that the presence of appreciable amounts of amino-nitrogen in the juice responsible for the development of colour during the boiling of the juice.

(*d*) *Factors affecting jaggery quality*.—Studies on the quality of jaggery and the factors responsible have received much attention. The problems was first taken up to improve the quality of jaggery produced in and around Kampli, Hospet taluk, where the jaggery produced is very black and does not keep long. Investigations showed that the defects of the local method were

(1) the cutting of the canes before they are sufficiently ripe, (2) the large capacity of the pans, (3) charging the pans with more juice as the contents boil down, (4) the non-removal of scum, (5) overliming, and (6) want of care and cleanliness in the manufacture. Apart from these obvious defects which could be rectified by propaganda it was also seen that variety, soil and nature of irrigation water were also factors affecting jaggery quality.

(e) *Irrigation water and quality of juice and jaggery.*—As a matter of fact, the study on the effect of irrigation water was suggested by the observation that canes grown in the wet lands of the Central Farm (under tank irrigation) yielded good jaggery with light colour whereas the same variety raised on a field irrigated with brackish water from a well produced at best only a brown-coloured jaggery in spite of all the care taken during filtration of the juice. Pot experiments with and without manure were laid out to study this problem, using rain water, tap water containing 150 parts of total salts per 100,000 and saline water containing 500 parts of common salt per 100,000. The results of experiments spread over five years, clearly established that irrigation with saline water had the effect of increasing the nitrogen and chlorine content of the juice. On the other hand the content of the phosphoric acid in the juice was increased by rain water and diminished by saline water. These findings are important because it is known that a high content of nitrogen and chlorine in cane juice is injurious, while high phosphoric acid is beneficial from the point of view of sugar and jaggery manufacture.

(f) *Physico-chemical studies.*—Very detailed investigations on the physical structure of jaggery samples, good and bad, were done. The studies included the macro and the micro structure of jaggery samples. The non-sugar organic matter content and the ash constituents of samples were estimated. It was established that apart from the sugar content, the non-sugar organic matter content was the most important factor that affected the keeping quality of jaggery samples.

Coconut jaggery studies.—The study of quality in coconut jaggery is closely associated with studies on cane jaggery but actually the coconut jaggery work is very much earlier and engaged the attention of the section nearly 30 years ago. The manufacture of coconut jaggery is a cottage industry on the West Coast but the product obtained was dark coloured and of very poor keeping quality. The jaggery is manufactured for local consumption from unfermented juice. To prevent fermentation the pots in which the juice is collected are limed inside. It was found that this lime was the chief factor responsible for the dark colour and poor quality of the jaggery. Apart from this, the crude methods of filtration and unclean vessels which carry contamination were also found to be responsible. Detailed studies showed that by the adoption of a simple sand filter and the use of alum for deliming the juice by throwing lime out of solution as a precipitate, the

colour and quality of jaggery could be improved. Actually samples prepared by the improved methods were kept for years in the laboratory side by side with dark coloured indigenous samples which were running into water within a few weeks of manufacture. During the investigation it was found that jaggery prepared from unfermented juice by the improved method was markedly crystalline in structure and showed very little glucose on analysis. From this the idea of preparing brown sugar from the coconut juice appeared feasible and a method was developed to manufacture brown sugar by stopping the boiling of the juice a little short of the jaggery moulding stage.

As already mentioned, this work was done nearly 30 years ago when there was no prohibition and coconut jaggery was manufactured as a side line from unfermented juice. There was therefore no need to follow up the studies which stopped as soon as an improved method for making jaggery was evolved.

Studies on rice.—The forms in which rice is consumed vary from tract to tract, the population having developed tastes and idiosyncracies for not only particular varieties but also for the particular way in which they are cooked. Several factors have contributed to the evolution of these different rice-eating habits and the chemistry section has attempted to elucidate these factors. Varietal and agronomic differences and their effect on chemical composition as also the effect of methods of preparation of the grain for consumption were studied. It was found that generally short duration types have a higher content of proteins and minerals than long duration rices. The coloured rices are again richer in protein and in ash constituents. The effect of irrigation was to raise the ash constituent but to depress the amount of protein. The biological values of the proteins of various samples of rice were also studied, by the use of laboratory animals for nutrition experiment. Short duration varieties showed higher biological values than long duration ones. Mill polishing of rice as well as washing before cooking brings about an appreciable reduction of protein quality. The proteins of short duration rices as well as of the unpolished grain contain a greater proportion of essential amino-acids like cystine, tryptophane, histidine, arginine and lysine—than the long-duration types.

Another investigation on rice quality was to study the fundamental differences between old and new rice, in other words, it was a study of the chemical changes occurring in rice during storage. New rice is supposed to be not so easily digestible and the object was to find out if and how new rice acquires desirable qualities on storing. The physical, chemical and microscopical properties of a number of samples of old and new rice were studied as also the starches prepared from them. By this investigation it was possible to follow the improvement of quality in rice with reference to volume expansion on cooking, the viscosity of the rice extracts, the reducing power of the extracts and the content

of amylose, amylopectin and phosphorus in rice starches and the size and structure of the starch granule. It was seen that old rice cooks better than new rice showing a greater expansion in volume. When rice is stored, the viscosity of the extract and of the "*Kanjee*" decreases. A study of the reducing power of the starch and its fractions showed that on storing there is a polymerisation of polysaccharides of low molecular weight into those of high molecular weight. During storage there is again an increase in the amylopectin content at the expense of amylose and soluble polysaccharides. The cold water extract of rice contains high amounts of phosphorus and there was evidence to indicate that as the rice becomes older, phosphorous compounds diffuse into the interior of the grain. Old rice starch has a greater water holding capacity, a higher phosphorous content and a smaller size of starch granule than starch of new rice.

Studies on the potato.—The initial study on the potato was the food value of all the varieties grown at the Agricultural Research Station, Nanjanad. The analytical data so obtained indicated that two varieties, *Great Scot* and *Royal Kidney* have the best food value. These two varieties are the most popular in the locality occupying nearly 95 per cent of the area and apart from other desirable qualities like short duration and high yield, the chemical analysis also showed them to be of high nutritive value. Another investigation was undertaken to study the causes of deterioration of Kotagiri potatoes. Early lifting of the Kotagiri potatoes, its appreciable mealiness, thicker peel and ill-balanced distribution of mineral, appeared to be factors contributing to deterioration. Even when the same variety, *Great Scot* was used as seed material in both the places, differences in physical and chemical properties were noticed. Supply of manurial deficiencies and provision of aeration during transport were suggested as remedies for improving the quality. The chemical analysis of flesh and peel of the different varieties for nitrogen, phosphoric acid and potash disclosed in general the following points :—(*a*) a greater percentage of ash, nitrogen and potash in the peel than in the flesh, (*b*) comparatively larger amounts of dry matter and phosphoric acid in the fleshy portion of all varieties, (*c*) no appreciable differences in the amount of the various mineral ingredients of the sample harvested early and late, (*d*) superiority of *Royal Kidney* in particular over the other varieties in regard to nitrogen, potash and phosphoric acid irrespective of soil conditions and time of harvest.

Preliminary studies on "Black heart" disease of stored potato on the Nilgiris showed that it was due to a physiological breakdown of the tuber which becomes unfit for consumption. The various factors responsible for this breakdown are being studied with a view to control the breakdown. More details will be found elsewhere, later on in this chapter under Plant Physiology.

Studies on tobacco.—Preliminary studies on the factors responsible for quality in Virginia tobacco were undertaken. The Guntur

area supplied necessary materials like leaf and soil sample for the study. The analytical data revealed that good quality leaf had a low content of salt and nicotine. The lower inferior grades were invariably characterized by a higher nicotine content and of mineral matter, especially lime and magnesia. Correlation between soil analysis and leaf quality was noticed. The soils on which good grade tobacco was grown were found to have a low salt content. Quality in Virginia tobacco was therefore found to be associated with low salt content in the leaf and with a soil of similarly low salt content.

Studies on the quality of chewing tobacco were started at the instance of the Government of India to find out the possibility of improving the *Meenampalayam* (Coimbatore) tobacco to the level of the Jaffna variety. The superior quality of the Jaffna tobacco was considered by the Marketing Adviser to the Government of India to be due to the nature of the micro-flora associated with it. It was suggested that by transferring the micro-organisms from Jaffna variety to that of *Meenampalayam*, the flavour of the latter could be improved. The results of the chemical and bacteriological investigations were as follows:—(1) The cured samples of the two varieties as received from their respective places of origin showed that Jaffna tobacco contained far less nicotine than the *Meenampalayam* and the preference of the tobacco addicts in Travancore to the former and the Coimbatore addicts to the latter is probably due to the difference in the nicotine content. (2) Growing the two varieties side by side on the Central Farm, Coimbatore, resulted in the production of a Jaffna type with as high a nicotine content as the *Meenampalayam* type at all stages of growth and curing and in the cured product. (3) Bacterial flora has nothing to do with the quality of the two types of tobacco.

The investigations led to the conclusion that soil and climatic conditions were the chief factors responsible for influencing the quality in the two types.

Coffee studies.—Studies on the quality of coffee were started at the instance of the Marketing Adviser to the Government of India who wanted to know the difference in composition between the two varieties *Coffee arabica* and *C. robusta*. It was found that *C. arabica* in the roasted condition had a better flavour though it was not possible to quantitatively measure it. It was however found that *C. arabica* in the roasted condition had a higher oil content than the other variety.

Banana studies.—Forty-two samples of different varieties of banana were collected and analysed for their mineral matter content and food value. The analytical data revealed that the outstanding variety was the red banana which had a total sugar content of 20·9 per cent and a non-sugar content of 13·8 per cent.

Some work was done on the keeping quality of bananas. Experiments were laid out and trees manured with wood ashes

(a good source of potash) produced fruits which kept 48 to 72 hours longer than fruits obtained from unmanured trees.

Pineapple studies.—This work was started to throw some light on the chemical changes occurring in the pineapple during growth. Periodical analyses of the fruits were done for sugar and non-sugar content. The data were helpful to determine the best period for planting and harvesting the crop.

Sweet potato studies.—Experiments were conducted with a view to prepare attractive products such as flour, biscuits, cake, bread and other comestibles as from cereal starch. Cakes and biscuits were made with 50 and 60 per cent of sweet potato flour respectively and consumers were unanimous in testifying to the excellence of the products in point of taste, aroma and appearance. Bread made out of 25 per cent of sweet potato flour was good but higher proportions were found unsuitable. *Chappathies*, *Kanjee* and eatables with proportions of grams mixed were other preparations tried on a small scale in the laboratory.

The storage of harvested sweet potato was also studied. Actually this was done in the several Agricultural Research Stations, five methods of storage being studied. Samples sent periodically to the laboratories at Coimbatore and Bapatla for examination showed that there was no difference between the sprouted and unsprouted tubers. There was however some evidence to show that during storage the sugar content increases while the starch decreases.

Beet-root studies.—Experiments were conducted to fix the optimum period for the harvest of the beet-root crop to ensure maximum sugar content. Two varieties, the *California* and the *Kashmir*, were under trial. From the results of analysis available it was concluded that the crop sown in September may be harvested in April. The harvest should not be delayed beyond the middle of May as deterioration in sugar content sets in.

Fodder grass studies.—This work was done in collaboration with the Government Lecturing and Systematic Botanist for the selection of grasses suitable for fodder by examining them at four stages of growth, viz., tender, prior to shot blade, in full bloom and after seed setting. Some of the grasses develop hydrocyanic acid during stages of their growth and may prove toxic. The object of the study was to find which of the grasses contained hydrocyanic acid, the amounts of it and if they could be fed safely. Altogether 18 samples were examined but of these only four, viz., (1) *Cynodon dactylon*, (2) *Cynodon plectostachyum*, (3) *Scheine revose* and (4) *Leftacholo obluriflora* contained hydrocyanic acid but except in the leaf which contained appreciable amounts even after seed setting the others contained low amounts only. Out of these four varieties, *Cynodon plectostachyum* is the famous Giant Stargrass, an introduction from South Africa. The bullocks experimented with relished this grass and maintained excellent health. No symptoms of toxicity were noticed after feeding the grass fresh

or wilted or cut at any stage of growth. This showed, apart from analytical figures, that the amount of hydrocyanic acid in this grass is well below the toxic limits.

Coriander studies.—Firms dealings with the coriander trade wanted advice on the quality of Indian coriander as compared to that in the European market. Samples of Indian varieties were obtained and analysed. It was found that the essential oil content of Indian coriander was low compared to the Russain and other foreign varieties. Based on this, advice was given to the concerned firms.

Ginger preservation.—A similar investigation, started at the instance of the trade, was on the preservation of ginger. This is a commodity which is exported for the European market and finds competition from other parts of the world. The problem is one of preserving the ginger so that it may be free from insect attack and preserve its quality and have an attractive colour. The normal method is to fumigate the rhizomes with sulphur dioxide before export. This was costly and not always efficient. A less objectionable method was required. As the result of investigations it was found that treatment of the rhizomes with milk of lime, followed by drying in the sun resulted in a satisfactory product.

Cashewnut studies on preservation.—Fresh cashewnut kernels were kept under different conditions of storage, namely, vacuum, carbon dioxide atmosphere, and under ordinary atmospheric conditions. The samples under different storage were analysed periodically up to six months, for acidity, rancidity, etc., besides examining them for insect infestation. The results indicated that the vacuum and carbon dioxide atmosphere are superior to ordinary atmosphere. It was also found that, provided the moisture content is within 5 per cent and the product is sterilized before packing, the kernels could be preserved in vacuum for over six months, without spoilage.

The viability of Kolinji seeds.—The aim of this study was to find out ways and means of improving the poor germination of *Kolinji* seeds sown as green manure for rice under normal conditions, so that seed rate could be reduced and more acreage covered by the available seed. To gain this objective, seeds were subjected to sand polishing besides treating them with sulphuric acid, sodium hydroxide, calcium hydroxide and lime water of different strengths. Of the various treatments, soaking the seeds in 95 per cent commercial sulphuric acid for 5 minutes followed by washing them with water till free from acid, gave the best results, the next best being treatment with 20 per cent sodium hydroxide.

Improvement of marginal lands.—Marginal lands of low fertility can be built up and improved gradually by growing green manure crops and ploughing them. But green manure crops only add nitrogen to the soil and further on such marginal lands green manures themselves will not grow well. It is known that phosphoric acid stimulates root-nodule formation in legumes. Using

this principle a method of improving marginal lands in the State is being tried. Experiments have been started recently in Tirunelveli district and the Agricultural Research Station, Koilpatti by growing legumes with application of superphosphate and ploughing them in, to supply plant food and organic matter to the succeeding crop. Two sets of experiments are conducted simultaneously, one on ryots' fields and the other in the Agricultural Research Station, Koilpatti, and the results are being watched.

Rubber from Cryptostegia vine.—Heve latex, the rubber tree, is the natural source of the raw rubber of the world; but during the Great War II, while Malaya and other rubber growing countries fell into Japanese hands, in all the countries of the world attempts to manufacture synthetic rubber or to investigate other alternative plant sources were being made. In India and in Madras State also these investigations were continued.

Among the many plants tried, *Cryptostegia grandiflora* showed much promise. This was a vine, which was capable of quick growth and the shoots when cut yielded a latex which could be collected and converted into rubber. Compared to *Hevea* rubber, the yield was very low and uneconomic, but the crisis caused by the rubber shortage warranted a detailed study. The investigation covered several aspects, methods of propagation from seed or cutting, the frequency of pruning, the method of collection of latex and the methods of coagulating the rubber from the latex collected and the economies of production.

Observations on the yield and quality of rubber from irrigated and unirrigated plots at Coimbatore, showed that except in the months of July and October, the irrigated plots yielded more, and the rubber obtained was of superior quality.

A method for the isolation of rubber from the leaf material by fermenting it, was also worked out, so as to make it feasible, in the event of any future necessity, for the production of rubber from this source.

Groundnut proteins—Studies.—The proteins of several indigenous agricultural products like cereals, pulses, grams, were isolated and from nutritional experiments it was established that groundnut proteins were superior in quality. It was therefore considered that a soluble and easily assimilable form of the protein would, by virtue of its nutritive property, be of value as a stimulant nourishment. The protein of groundnut cake was rendered soluble by a special process. With this substance as a base, a palatable tonic was prepared containing 7·75 per cent : of solube proteins in addition to other substances commonly found in such tonics.

Chemistry of fungicides.—An accurate knowledge of the chemistry of Bordeaux mixture used for spraying is necessary for the preparation of a mixture with effective fungicidal properties. As a result of careful study it was established that the previous views on the composition of the precipitate obtained by mixing one

per cent. solution of copper sulphate and lime water were rather erroneous, and that the compound formed is only copper hydroxide which has absorbed at its surface large quantities of calcium sulphate, and not a basic sulphate of copper as was usually assumed.

Food and industrial products.—In a previous chapter. " Nutrition ", mention has been already made of the successful preparation of malt from local cereals. The work actually started 33 years ago and as the result of these investigations, the Government Malt Factory at Coimbatore is successfully working now producing quantities of malt food and malt extract impregnated with Vitamin D and Shark Liver oil. A number of associated problems have also been studied, these have not come to the stage of factory production, but short notes about them are given in this section to indicate the possibilities of future industrial development.

At the Madras Industrial Exhibition in December 1917, a number of articles of food and industrial products were exhibited by the Government Agricultural Chemist and were awarded a gold medal for their excellence. These were all prepared in the Coimbatore laboratory from indigenous agricultural produce and are capable of replacing similar imported articles. The articles finally prepared as exhibits may be classified as follows: (1) Infant and invalid foods, (2) Breakfast and other foods, (3) Beverages, (4) Cheese and Lactose, (5) Casein and casein products. When work was taken in hand, it was realized that so far as foodstuffs were concerned the primary problem was the production of a good malt and malt extract, these being important constituents of many patent foods. This led in the first instance to the search for a grain of food malting capacity, and of several cereals tried, sorghum answered the purpose suitably. With malt preparation from sorghum thus assured, foods of the type of Benger's, Mellins, Horlicks, Sanatogen, and Plasmen were all prepared by suitable blending. Breakfast foods like grape nuts, shredded wheat, vermicilli, desiccated coconuts, candied peel and parched foods from rice and bajra with and without malt were also prepared. Attempts to make ready soup flours from pulses, and of starches from cereals, bananas and tubers were also made successfully. Beverages like orange and lime juice sterilised, sorghum beer (from malted sorghum) also received attention.

The preparation of by-products from milk becomes important only when our country becomes self-sufficient to meet the needs of the population for milk, but the possibilities have already been examined. Cheese, lactose and casein were the products obtained from milk and from the casein as a base it was shown that paints, varnishes and distempers, as also photographic films, and toys could be made.

Although the Malt Factory at Coimbatore has started functioning as an indenpendent unit for the last eight years, problems

connected with the industry still continue to be examined in the Chemistry section. Among these may be mentioned the blending of malt with other flours to prepare bread, cakes and biscuits; the preservation of malt food and malt extract and the factors that govern spoilage, the use of diastase from *Aspergillus oryzae*, to cheapen production, the use of sweet potato and other starches as the sources of malt for preparing the extract and the preparation of foods like Ovaltine.

Ovaltine, besides other constituents, requires Cocoa as one of the ingredients and some work has been done on the method of preparing food Cocoa from Cocoa pods grown on the Burliar gardens.

Work on activated carbon.—A process for the manufacture of active carbon comparing favourably in decolorising power with expensive imported carbon, has been developed. The raw material is paddy husk which is a waste product from rice mills. The process consists in charging the husk into closed iron pipes and heating it to 700° to 800° C. out of contract with air. The charred husk is then treated with Caustic soda solution and then washed free of alkali. The cheapening of the cost of production, the standardisation of the product and the ramification of the used active carbon, also received attention. Further investigations were carried out to improve the efficiency, by using other reagents and other waste material, e.g., groundnut shell. The trials showed that by further treatment with calcium chloride, the improved product obtained was twice as powerful and compared very favourably with imported carbon. Groundnut shell active carbon could be prepared by treatment of powdered shell with zinc chloride solution.

By using active carbon prepared from paddy husk, for the clarification of sugarcane juice, the possibility of preparing what is known as "cream jaggery" was demonstrated. In the malt factory at Coimbatore, active carbon is being used for the clarification of the extract. It has also been successfully used for the clarification of oils and some local merchants have adopted this method with profit, for placing on the market refined and clear oils.

Manufacture of Agar-agar from Seaweed.—Agar-agar is a jelly like substance obtained from seaweed and is used as an article of diet in the Orient, Japan, Ceylon, Malaya, Indo-China and China. It is also in demand by bacteriologists and medical men as the most suitable medium for culture preparation. During the last world war there was a shortage of agar-agar and the need was felt for it in the manufacture of Cholera vaccine. Investigations were started in 1943, for preparing agar-agar from seaweed. A preliminary survey showed that out of many algae found on the Coromandel coast, *Gracilaria lichenoides*, found abundantly in the sea between Ceylon and India, could be a fruitful source. Investi-

gations were started and as a result the final method of preparation was evolved, which is indicated in the flowsheet below.

Agar-agar—Flowsheet of porcess.

Raw seaweed.

↓

Soak in one per cent hydrochloric acid for 90 minutes.

↓

Wash in water till acid free.

↓

Bleach and dry in the sun.

↓

Extract in boiling water successively.

↓

Combine extracts and set to jelly.

↓

Place jelly in tall cylinders and add three times its volume of sweet water.

↓

Allow to stand for 48 hours.

↓

Filter through muslin.

The yield was found to be 20 per cent of the dried weed and examination in the laboratory showed that it conformed to the standards prescribed by the British Pharmacopœa and compared favourably with agar-agar commonly used in biological laboratories.

Vegetable milk from oilseeds and pulses.—In the year 1945 investigations were started to find the possibilities of preparing milk substitutes from oilseeds and pulses other than Soyabeans. Groundnut, cotton seed and coconut among oilseeds and horsegram, bengalgram and lab-lab among pulses were tried. A process was developed by soaking in water and extraction through cloth the emulsion formed from the crushed seed. The colour, consistency, flavour, chemical properties of the milks were all determined and it was found that cotton seed milk was equivalent in nutritive value to cow's milk.

The milks were tested for their palatability both as milk and added to coffee and tea. The taste of the milks from pulses either alone or with coffee was unpalatable due to the characteristic flavour of the grains. Coconut milk and cotton seed milk when mixed with coffee were not noticeable but when taken alone they had their characteristic taste.

Plant Physiology.

In view of the great advances made in other countries in the practical application of plant physiological research a section on plant physiology was opened in 1946 at the Agricultural Research Institute, Coimbatore. Certain promising lines were taken for investigation and the progress made in these during the period 1946 to 1950 is indicated in outline below.

Vernalisation in rice.—Seven varieties of rice, of three duration groups, short, medium and long, were studied under four types of vernalisation treatments and the effects on growth, tillering, flowering and yield were observed both in pot cultures and in the field. The results indicated that a good deal of varietal differences exist even in the same crop in the response to vernalisation treatments. It was also noted that vernalisation was likely to be more useful as a means of improving grain yield in rice than for reducing the duration. In the case of responsive varieties like GEB 24, AKP 5 and AKP 8 the grain yields were increased by 12 to 38 per cent over the controls. In straw yields too, there was a similar improvement but not quite so marked as in grain.

Pretreatments with phosphate solutions and growth hormones.—Studies were also initiated on the possibility of improving crop yields by soaking the seeds before sowing in suitable strength of various phosphate solutions, and the results so far observed indicate that this method has great possibilities in the direction of improving crop yields both by supplying the major elements like phosphorous and potash and also by rectifying trace element deficiencies where they happen to exist in the soil. The investigations are being continued.

As a variant of this technique presoaking paddy seeds in a 20 parts per million solution of the growth hormone indole-acetic acid was found to increase the grain yield by about 18 per cent. On potatoes too, it was observed that tuber yields were capable of being increased up to 30 per cent by soaking the seed tubers before planting them in 60 to 100 parts per million dilutions of growth hormones, like indole-acetic and indole-butyric acids.

Certain preliminary trials were also made on the effect of presoaking seeds in various dilutions of pregnant cow's urine on the basis of their containing growth promoting hormones. The trials were made at the Millets Breeding Station. In the case of sorghum it was noted that none of the treatments tried gave any significant increase over controls in yield. With *bajra*, soaking in

undiluted urine resulted in a significant increase in yield while with ragi, presoaking in one per cent and 100 per cent urine gave plants that were earlier than the control by ten days and seven days respectively. The same trial when repeated in pot cultures showed that presoaking increased the yield of grain and straw, besides hastening the flowering by three to eight days. Similar trials with Setaria (Strain CO. 2) failed to show any significant increase over control.

At Buchireddipalayam Rice Research Station, dibbling cow-dung-treated paddy seeds gave a well established crop earlier than transplanting. In yield it was on a par with a transplanted crop but significantly better than broadcasting.

The effect of pretreating bengalgram seeds with different concentrations of potassium phosphate and calcium phosphate solutions was studied in 1949 at Coimbatore. Soaking in a two per cent solution of dibasic potassium phosphate showed an increase of nine per cent over control but owing probably to the abnormally droughty season in 1949 and general low level of yields in this bengalgram crop, the difference was not statistically significant. Further work is clearly desirable to assess the full scope and potentialities of this technique of presoaking seeds for improving crop yields.

Effect of trace element sprays.—When paddy plants were sprayed about one month after being transplanted with suitable dilutions of copper, zinc and manganese sulphates, it was found that the grain yields were improved up to a maximum of 24 per cent over unsprayed controls.

In straw yield too, the effect was similar but less pronounced than in grain. These investigations also are being continued.

The effect of supplying other trace elements to crops, such as boron to sweet potatoes and lucerne in the form of borax is also under investigation. The results so far obtained seem to show that about 40 pounds of borax applied one month before planting is capable, under favourable conditions, of improving tuber yields in sweet potatoes by as much as 24 per cent and the yield of lucerne by about 8 to 10 per cent. The specific conditions under which these increases are possible require further investigation.

Black heart in potatoes.—During World War II, when large quantities of potatoes had to be stored and sent by rail from the Nilgiris to Ranipet for dehydration for military uses, a disease known as "black heart" assumed serious proportions. The disease was unusual in that no fungus or bacteria were involved but was due to an injury of the tuber tissues brought about by overheating in storage and lack of proper ventilation. The name "black heart" too was quite an appropriate one, because the main symptom was a blackish discoloration in the heart of the tuber, which was evident only on cutting it open through the middle as an oval or heartshaped patch, sharply set off from the surrounding creamy-white, healthy tissues.

An investigation was taken up in 1948 to find out the factors involved in causing this trouble and for devising proper remedial or preventive measures. The results of this investigation showed that under normal conditions of aeration, humidity and tempera-true, black heart does not develop upto ten weeks in storage but if the tubers are kept in very dry conditions or at temperatures over 85° F, the disorder develops within two or three weeks in storage. If, on the other hand, the tubers are stored in a moist atmosphere with the temperature not exceeding 80°F they could be kept free of black heart up to 12 weeks in storage. Another interesting fact that was observed was that the popular Nilgiris variety, *Great Scot*, seemed to be more resistant to black heart under South Indian conditions than other varieties studied elsewhere in the colder countries of the west.

WEEDS AND WEED CONTROL.

A weed is a plant in the wrong place. The word suggests a useless harmful or ugly plant that persists in growing where it is not wanted. A plant may be harmless or even useful and still be a weed under certain situations because a plant is regarded as a weed not merely on its habit or characteristics but in relative position with reference to other plants and man. In a country like the United States of America the loss due to weeds is estimated at over 300 million dollars, a loss greater than what is suffered from insect pests, plant diseases and livestock diseases. The loss cannot be much less in a country like India which is far less advanced in weed control measures.

Weeds that are regarded as serious pests by farmers are usually the aggressive perennials, many of them with a free seeding habit and efficient means of seed-dispersal and a wide tolerance of soil and plant nutrients that weeds cause, they are also the cause of an indirect loss as hosts for insects, fungi and virus diseases. Economic factors arising from maladjustments of land-tenure, neglect of drainage and proper soil management, over-stocking or over-grazing, all these too increase the number of weeds in agricul-aural lands.

The source of weeds is from impurities in seeds, hay and feed-ing stuffs, ballast from freight cars and boats, farmyard manure, farm implements, packing materials and disseminated by wind, water and animals. The losses are through reduced yields of agricultural crops, increase of operating costs on farms and injurious effects by weeds serving as hosts of pests and diseases transferable to crop plants. Some common weeds like *Lochnera pusilla K. Schum Datura stramonium* and *withania somnifera Dun* are poisonous to livestock. A few weeds have prominent thorns and spines and are capable of causing mechanical injury to livestock and labourers, e.g., *Trimulus, terrestris, Xanthium aristida* sp. The presence of weeds in farm produce decreases their sale value considerably.

Weeds are not however quite an unmixed evil as they can sometimes be made use of as green manure adding humus and plant nutrients to the soil. They also serve as a cover crop for preventing soil erosion by wind or water. Quite a few can be utilized as forage plants when more palatable plants are scarce, e.g., *Portulaca oleraceah, Amaranthus viridish,* and a number of weeds have valuable medicinal properties as well.

A list of common weeds is given below :—

Foreign weeds introduced into South India.

(1) *Coronopus didymus*	A tropical American weed is seen spreading in Ootacamund on road sides.
(2) *Saponaria vaccaria L.*	A plant of the Mediterranean region, which has become a weed in wheat fields in South India.
(3) *Spergula arvensis L.*	A plant of Europe, which is now a pest in the Nilgiris.
(4) *Modiola caroliniana* G.Don. ..	Is common in Ootacamund.
(5) *Conyza ambigua DC.*	(Erigeron linifolius Willd). An American plant is spreading throughout South India.
(6) *Flaveria australasica H.L.* ..	Of Australia introduced probably by Australian horse dealers.
(7) *Tridax procumbens L.*	Of tropical America which is now abundant everywhere from the Himalayas to Cape Comorin.
(8) *Galinsega parviflora* Cav. ..	Of Australia.
(9) *Centaurea melitensis*	Of Europe now found in the Nilgiris.
(10) *Asclepias curassavica L.* ..	....
(11) *Martynia annua L.*	(Tigers' claws)—from Mexico.
(12) *Eichrornia crassipes Solms* ..	(Water hyacinth)—a very serious pest in the backwater areas of Travancore.
(13) *Alternanthera echinata Smith* ..	A tropical American procumbent herb which is now a very common weed in South India especially Coimbatore, Madras and Mangalore.
(14) *Acanthospermum hispidum* D.C.	....
(15) *Croton sparsiflorus Mor*	....
(16) *Emex spinosa campd.*	Very common on the Nilgiris.
(17) *Pilea muscosa* Lindl.	A tiny Urticaceous American plant known as the artillery plant which is now seen on the hills as a troublesome weed.
Pond weeds	These cause a lot of trouble by blocking up irrigation channels, polluting drinking water by decaying leaves and often hindering fish culture.

(1) *Nymphoea pubescens* Willd.
(2) *Nelumbium speciosum* Willd.
(3) *Limanthemum cristatum* Gris.
(4) *Utricularia stellaris* L.f.
(5) *Ceratophyllum demersum.*
(6) *Hydrilla verticillata* Royle.
(7) *Vallisneria spiralis* L.
(8) *Ottelia alisimoides* Pers.

(9) *Pistia stratiotehs.*

(10) *Lemna* sp.

(11) *Marsilea quadrifolia.*

(12) *Chara* sp.

Poisonous weeds.

(1) *Datura fastuosa* L. and *Datura metel* L.	*Datura stramonium* L. all parts of the plants are poisonous.
(2) *Withania somnifera* Dun ..	Berries are poisonous.
(3) *Lochnera pusilla* K. shum. ..	
(4) *Crinum defixum* Ker. ..	
(5) *Abrus precatoricus.*	

Parasitic weeds.—Orobanche, Striga sp. *Cuscuta chinensis* Lam. *Cassytha filiformis* L. and *Loranthus longiflorus* Desv.

List of common weeds of economic importance.

Serial number and Botanical name of weed.	*Family.*	*Telugu name.*	*Tamil name.*	*Economic importance.*
1 Argemone mexicana, L.	Papaveraceæ	Bramhadandu	Bramhadandu	Seed yields painters' oil also useful for skin diseases.
2 Nasturtium indicum, Dc.	Cruciferae	....	Kattukadugu	....
3 Gyandropsis pentaphylla, Dc.	Capparidaceæ	Vavinta	Nai Velai; Kattu-kadugu.	Oil from seed useful in skin diseases; vermifuge.
4 Cleome viscosa, L.	Do.	Kukka vavinta	Nai kadugu	Seeds antheloentic and carminative.
5 Cleome Chelidonii, L.f.	Do.	....	....	....
6 Ionidium suffruticosum, Ging.	Violaceæ	Ratnapurusha	Purusharathnam; Orela thamarai.	Highly medicinal, for consumption, asthma and leprosy.
7 Polygala chinensis, L.	Polygalaceæ	....	....	....
8 Portulaca oleracea, L.	Portulacaceæ	Peddapavilikura	Paruppu keerai	Fifty to seventy thousand seed produced by each plant; maximum recorded is 125,000; vitality of seed for 30 years.
9 Portulaca quadrifida, L.	Do.	Corrigeddam	Siru Pasarai	....
10 Abutilon indicum, G.Dom.	Malvaceæ	Tutturu Benda or adavi benda.	Tutti	Bark astringent, diuretic.
11 Hibiscus vitifolius, L.	Do.	Karupatti	Mani-tutte	Good fibre can be obtained.
12 Corchorus olitorius, L.	Tiliaceæ	Perinta koora	Perum purmakku poondu.	Jute obtained; charcoal prepared from stalks can be used for gun-powder.
13 C. trilocularis, L.	Do.	....	Punnakkupoondu	....
14 Tribulus terrestris, L.	Zygophyllaceæ	Palleu	Nerinji	Plant diuretic and aphrodisiac.
15 Tephrosia purpurea, Pers.	Papilionateæ	Vempali	Kolinji	Decoction of fruit kills intestinal worms. Plant laxative and tonic.
16 Phaseolus trilobus, Ait.	Do.	Pillipesara	Panipayir	Green manure and fodder plant; decoction febrifuge.
17 Cassia occidentalis, L.	Cæsalpinoideæ	Kasivinda	Thagarai; Peyavarai.	Leaves purgative and for itches, seeds also medicinal.
18 Clitoria ternatea, L.	Papilionateæ	Neelagentana	Kuvalai	Highly medicinal.
19 Ammania baccifera, L.	Lythraceæ	Agni Vendapaku	Kalluruvi	Leaves blister skin; juice given to animals in heat to reduce sexual appetite.

20 Trianthema portulacastrum,	Aizoaceæ ..	.. Galjeru ..	.. Saranai ..	.. Vegetable antidote for alcoholic poison; increases milk secretion in women.
21 T. decandra, L.	Do. ..	.. Tella Galjeru	.. Vellai Saranai	.. Root used in asthma; juice of leaves dropped into nostrils relieves one-sided headache.
22 Mollugo lotoides, O.Kze. ..	Do. ..	.. Chadarasikoora	.. Siruvayal ..	.. Young shoots cooked and eaten; dried plant purgative in abdominal diseases.
23 Centella asiatica	Umbelliferæ ..	.. Saraswathi Aku	.. Vallaraikerai ..	.. As fodder increases milk secretion in cows; root blood purifier.
24 Oldenlandia umbellata, L. ..	Rubiaceæ ..	.. Chiriveru ..	.. Saya vair ..	.. Once cultivated for red dye in root back; root specific for snake bites; leaves expectorant useful in asthma and consumption.
25 Grangea maderaspatna, Poir.	Compositæ ..	.. Masipatri ..	.. Masipatri ..	.. Leaves medicinal for hysteric spasms and irregular menses.
26 Xanthium strumarium, L. ..	Do. ..	.. Marula mathangi	.. Marul Oomanthan	.. Oil from seeds medicinal; poisionous to cattle in America and Australia.
27 Eclipta alba, Hassk.	Do. ..	.. Guntakalavaraaku	.. Karasaranganni	.. Used in asthma, rheumatism and other diseases; leaf remedy for scorpion sting.
28 Sonchus arvensis, L.	Do. ..	.. Jangalitamaku	.. ....	Root given in jaundice; plant good fodder.
29 Lochnera pusilla, K. Schum.	Apocynaceæ ..	.. ....	Milagai poondu	.. External stimulant in lumbago.
30 Calotropis gigantea, R.Br. ..	Asclepiadaceæ	.. Jilledu ..	.. Erukkam ..	.. Stem yields strong fibre; green manure plant; the juice contains active principle "mudarine" and is purgative; leaves with pepper used in snake bite.
31 Heliotropium indicum, L. ..	Boraginaceæ	.. Thelukondi chettu	.. Thel kodukku	.. Leaf juice for scorpion sting and hydrophobia; fruit decoction for asthma, etc.
32 Evolvulus alsinoides, L. ..	Convolvulaceæ	.. Vishnukranti ..	.. Vishnukirandi	.. Bitter tonic and for rheumatism; promotes conception.
33 Convolvulus arvensis, L. ..	Do.	.. ....	Bhumichakra poondu.	Root purgative.
34 Merremia emarginata, Hall.f.	Do.	.. Elikajemudu ..	.. Elikathukeerai	.. Diuretic, given in rat bite.

List of common weeds of economic importance—cont.

Serial number and Botanical name of weed.	*Family.*	*Telugu name.*	*Tamil name.*	*Economic importance.*
35 Solanum Xanthocarpum, Sch. and wendl.	Solanaceæ	Nelavakudu	Kandan kathiri	One of the "Dasamulikas" of Hindu medicine for cough, asthma and fever.
36 Physalis minima, L.	Do.	Kupanti	Thakkali	Tonic; when applied to breasts in the form of paste with rice water, it stimulates increased secretion of milk.
37 Datura fastuousa, L.	Do.	Nalla Ummetta	Umattam	Poisonous; whole plant is medicinal.
38 Moniera cuneifolia, Mielx.	Scrophulariacea	Sambranimokka	Neer brahmi	Whole plant nervine tonic and is used in the treatment of insanity and rheumatism.
39 Ocimum sanctum, L.	Labiateæ	Thulasi	Thulasi	Infusion of leaves for Malaria.
40 O. canum, Sims.	Do.	Kukka-thulasi	Nai-thulasi	Seed decoction removes throat phlegm in epilepsy.
41 Boerhaavia diffusa, L.	Myctaginacæ	Atikamamidi	Mukkurattai	Highly prized in Ayurveda. Decoction of root for rheumatism and asthma.
42 Achyranthes aspera, L.	Amarantaceæ	Uttareni	Nai-Uruvi	Medicinal.
43 Aerva tomentosa, Forsk.	Do.	Peddapindikonda	Poolai keerai	Flowering tops used for stuffing pillows, parthenogenetic seed.
44 Aristolochia bracteata, Ritz.	Aristolochiaceæ	Gaditha gadapaaku	Adu thinna pallai	Kills maggots in foul ulcers; purgative and anthelmentic.
45 Euphorbia hirta, L.	Euphorbiaceæ	Nana-balu	Ammaru paccharisi	Useful in bowel complaints, large demand in drug market.
46 Croton sparsiflorus, Mor.	Do.	Verrimerapa	Nai milakkai	Green manure.
47 Acalypha indica, L.	Do.	Kuppinta chettu	Kuppaimeni	Leaves laxative and useful in consumption.
48 Eichhornia crassipes, Solms.	Pontederiaceæ	Pichi thamara	Akasa thamarai	Pest Act applied.

Weed control.—The methods of controlling weeds may be grouped as below, (*a*) Mechanical—pulling out by manual labour, cutting, mowing or spudding (digging out) tillage or by burning, (*b*) by irrigation, (*c*) smothering or crowding out by thick sowings or by growing crops that cover the ground completely smothering the weeds, (*d*) biological methods—by release of suitable insect pests, and (*e*) by chemical methods utilising herbicides. Legislation may also be found necessary to enforce the proper control measures, for instance, in Alberta (U.S.A.) Agricultural Inspectors are empowered to order the partial or complete destruction of grain or hay crops containing noxious weeds. In Madras, water hyacinth is declared by law as a noxious weed and ordered to be destroyed wherever it occurs (under the Madras Pests and Diseases Act 1919 as amended by the Madras Act VII of 1925). Under section 3 (1), clauses (*b*) and (*c*) of the Act, the Government also prohibit the transport of this weed from one village to another or from one water source to another. The following are empowered to act as inspecting officers for the destruction of this weed, Revenue Inspectors, Minor Irrigation Overseers and Supervisors. If an inspecting officer gives notice to the owner of a place where the plant is found, e.g., well, tank or pond, it should be removed immediately, otherwise the officers will remove the weed and recover the cost from the owner.

The following are the places where the Agricultural Pests and Diseases Act was enforced :—

Ghumsur, Berhampur, Surada, Sompeta, Chatrapur, Ichapur taluks in Ganjam district (now in Orissa State), Tanjore district, Madurai district, Bapatla taluk in Guntur district, Godavari district, Ponnani, Kottayam, Palghat, Ernad, Kurumbranad taluks of Malabar district, Vriddachalam, Chidambaram and Tindivanam taluks in South Arcot district, Tiruchirappalli taluk, Vizianagaram municipality and Tanuku and Narasapur taluks of West Godavari district.

Biological methods.—In Italy and New Zealand fungi have been utilised to destroy weeds, cultures being prepared and the spore suspensions sprayed over the weeds. Good results have been claimed for this method. In Madras, prickly-pear (*Opuntia sp.*) was a most troublesome weed until the advent of the Cochineal insect from Australia (*Dactylopius sp.*). Similarly the weed, Lantana has been controlled by the Lantana bug.

Chemical control of weeds.—The use of chemicals for keeping down weeds has come to the forefront in recent years, particularly the type of chemicals known as selective herbicides. Previous to the discovery of these " hormone " type of herbicides, other chemicals were in vogue such as various phenolic compounds from products of coaltar distillation, sodium chlorate and sulphuric acid but these were non-selective in action, poisonous to cattle and highly corrosive and so they needed great care in handling as well as special equipment for spraying them in fields. The potentialities

and limitations of selective herbicides are still not very clearly delimited but it seems certain that agricultural practice would be definitely modified in the course of a few years by the availabilty of these chemical aids to clean cultivation.

In 1932, the eradication of *Alternanthera echinata* (*Khaki weed*) and *Cyperus rotundus* (*Nut grass*) was attempted by various methods. Repeated ploughings at short intervals with an efficient mould board plough were effective in destroying existing weeds but this did not help in destroying the viability of seeds nor the deep seated underground portions, especially in the case of nut grass. Sugarcane trash spread over the weeds to a depth of 6 to 12 inches helped to destroy the weeds by smothering them in about three months time. Sodium arsenite destroyed the weeds in three days, but being poisonous to cattle, its use could not be recommended for general adoption.

More recently in 1949, certain preliminary trials have been made at Coimbatore on the effect of priprietary hormone weed-killers like ' Methoxone ' on water hyacinth. A similar product ' Agroxone ' has been tested at Bapatla and was found to be effective against *Grangea maderaspatana Poir, Mollugo oppositifolia L., Boerhaavia repens L., Heliotropium ovalifolium Forsk, Croton sparifiorus Poir, Oldenlandia umbellata L.,* and *Amaranthus spinosus.*

A good deal of systematic trials and investigations are however necessary before the merits and economics of the numerous products that are now put on the market can be assessed with any degree of definiteness. Research is also necessary to determine for each type of weed the type of chemical that is the most efficacious, its dosages, manner and time of application, the inter-relations between weeds and sprays, and the weather conditions that precede and follow the spraying treatments. None of these weed killers is a panacea for bumper crops and none eliminates proper cultivation and soil management though they would no doubt be of great help in these days of food shortage and labour shortage.

The future.—Having studied so far about the weeds and their economic importance, the future plan of action will be discussed hereunder :—

Reliable information on weedicides is not available for the ryot to go in for these weed killers, though they are widely advertised and far-reaching claims advanced. A great deal of research is required mostly of the nature of field experiments in the important research stations on the following lines: (1) Experiments to determine the dosage required to kill the common weeds in cereals (rice, sorghum, bajra and maize) under Madras conditions. (2) A series of experiments to determine the minimum doses which will effectively control certain special weeds under practical conditions on a large scale, notably water hyacinth, striga, salvinia, and pistia. (3) Experiments with different types of machinery to determine their usefulness under various conditions and the cost

of treating a given area with each machine. (4) Experiments on spray adjuvants (e.g.,emulsified oils) and their efficacy in improving the spreading or sticking qualities of the spray solutions when they have to be applied to weeds with waxy or hairy leaves. (5) Extensive propaganda for the control of weeds where the method is clearly profitable (e.g., water hyacinth and striga). The example of Denmark where " the State makes annual grants to Agricultural societies for the purposes of awarding prizes to members of weedless fields " (Long—1929) may be followed by the Madras Government. The Madras Government may pass Acts with suitable modifications on the model of the Adulteration of Seeds Act of Great Britain, Weeds and Agricultural Seeds Act of Ireland and the Seed Control Act of Canada. Short-term leases and consequent neglect of weeding should be remedied by suitable legislation. " The Department of Agriculture should arrange for certification of weed-free rice crops for use as seed, and for the provision of seed cleaning machinery for hire or sale to growers and rice merchants. The Department of Agriculture should be enabled to undertake investigations into methods of direct control of weeds and into methods of pasture and grazing improvement." (Imperial Agricultural Bureaux Publication No. 38—1947). What is important than legislation is co-operation among all those concerned and a firm determination on the part of land owners and tenants to get rid of harmful weeds. Hence, the ryot should be educated on the subject by lantern slides, films, etc., and made to realise the importance of weeds; thus the enlightenment of the ryot is the true solution for all the economic and social problems of the Madras State including the weeds and fodder problem.

Bacteriology.

The Bacteriology Section was started in the year 1921 with the appointment of an Agricultural Bacteriologist in the Indian Agricultural Service. The section was closed down the very next year. The post of Agricultural Bacteriologist was revived in the year 1927, the post being in the Madras Agricultural Service and under the administrative control of the Government Agricultural Chemist.

The important items of research work carried out in this branch of the section are given below :—

1. *Solubilization of Tiruchirappalli phosphate by sulphonication methods.*—Trials were made to increase the availability of Tiruchirappalli phosphate by composting the finely ground material with sulphur, cattle manure and soil. The optimum proportions were found to be 25 parts of cattle manure for every 75 parts of soil and 4 parts of sulphur for every 20 parts of Tiruchirappalli phosphate. Eighty to eighty-five per cent of the total P_2O_5 was rendered available (as judged by solubility in 2 per cent

citric acid) in 60 days. Vegetation tests indicated the composted phosphate to be inferior to super-phosphate or bonemeal. At the then prevailing prices of sulphur and super the method was found to be uneconomical.

2. *Isolation and study of sulphur oxidizing bacteria.*—Pure cultures of sulphur oxidibing organisms were isolated and their physiological characters studied. A new species was isolated.

3. *Nitrogen fixation by non-symbiotic bacteria*—(a) *Azotobacter inoculation of cereals.*—Pot and field experiments were conducted to determine the effect of inoculating sorghum seeds with azotobacter prior to sowing. Increased yields of both grain and straw were obtained and the increases were statistically significant. The response due to inoculation was greater when lime and phosphates were applied to the soil.

(b) *Nitrogen fixation in swamp paddy soils.*—Paddy soils were inoculated with azotobacter alone, clostridium alone and with both and the effects on paddy yields and the oxygen demand of the drainage waters studied. Inoculation with azotobacter only gave the best results. Azotobacter plus clostridium depressed the yield and increased the oxygen demand of the drainage water.

4. *Groundnut nodule organisms.*—Nodule bacteria from six varieties of groundnuts were isolated and their morphological, physiological and other characteristics studied.

5. *Legume studies*—(a) *Cross-inoculation studies.*—The root norule organisms of the legumes commonly grown in South India were isolated and studied. Cross-inoculation experiments were conducted and two new cross-inoculation groups were discovered—the cicer group and the daincha group. *Sesbania grandiflora, sesbania specioca and sesbania miscrocarpus* belong to the latter group. Horsegram, lab-lab, pillipesara, indigo, wild indigo and blackgram fall in the cowpea group

(b) Field scale inoculation of several legumes were tried and increased yields ranging from 10–30 per cent were obtained.

(c) Soya bean and berseem which are new crops to this State failed to grow when tried at the various Agricultural Research Stations due to the absence of the specific root nodule organisms in the soils. Cultures of nodule organisms specific to these new crops were isolated and supplied.

(d) *Factors governing nodules formation and Nitrogen fixation.*—Sunlight, moisture, efficiency of the bacterial strain and the nature of the host plant were found to affect profoundly nodule formation and N fixation.

6. *Photo-nitrification.*—Dhar's theory that sunlight by itself produces nitrification was found to be untenable. Sterile and unsterilized soils were exposed to light for periods ranging from 300–600 hours. Control flasks blackened on the outside to exclude light were also filled with sterile and unsterilized soils. Analysis of the soils at the end of the experiment showed that only in the

unsterilized soils there had been nitrification whether exposed to light or not.

7. *Associated growth of legumes and cereals (irrigated).*—Redgram, greengram, blackgram, cluster beans and soya beans were grown in association with chitrai cholam (irrigated) in varying proportions. Half cholam and half pulse or three-fourths cholam and one-fourth pulse gave the best monetary return.

8. *Fermentation of molasses to power alcohol.*—Efficient cultures of Saccharomyces ellipsoides were isolated and the optimum conditions for the production of alcohol from molasses were worked out. Under optimum conditions 22 per cent of alcohol by weight or 27·5 per cent by volume was obtained.

9. *Microbiological flora of soils as influenced by manurial treatment.*—Periodical examination of the soils from the 'no manure' 'N+K+P' and 'cattle manure' plots was conducted. The cattle manure treatment gave the highest count followed by N+K+P. The bacterial population was highest during the rainy season, and least during summer. Close correlation between microbial population and crop yields was noticed.

10. *Examination of wet, garden land and dry land soils for algæ and protozoa.*—Large numbers of active protozoa were found in all the soils. The number of cysts was high in the dry land soil. The algæ population was highest in the wet land soil and least in the dry land soil.

11. *Bacteriological examination of milk from the College dairy and outside milk (Co-operative Milk Supply Union and villages round about).*—Periodical bacteriological examination at different seasons of the year of milk from the College dairy and outside milk was conducted. The dairy milk was found to be far superior to the outside milk and to conform to the standards laid down in advanced countries. Milk produced in the afternoon at the dairy was better than the morning milk which was traced to be due to exposing the vessels to the hot sun in the middle of the day, thus killing the contaminants. The main source of contamination of morning milk was traced to the utensils which accounted for nearly 80 per cent of the contamination. Steaming the vessels and drying in the sun reduced this contamination considerably.

12. *Keeping quality of milk.*—Boiling the milk for 5 minutes destroys most bacteria—even those of highly contaminated milk (B. coli, etc.). On keeping the boiled milk the multiplication of the bacteria is at a very low rate for the first three hours and then comparatively rapid, reaching a peak during the ninth hour. The time-honoured practice of boiling the milk is thus shown to be a safe one.

13. *Milk transport.*—An investigation in collaboration with the Indian Dairy Institute at Bangalore on the best method of

sending milk by train to distances of 250 miles and within 12 hours from milking to marketing was undertaken. Pasteurisation and the use of tin cans with wet gunny jacket was found to be the best method. Packing in mud pots was found to keep the milk cool and fresh. But the pots have to be changed frequently.

14. *Miscellaneous investigations.*—Among the miscellaneous investigations the following may be mentioned :—

(*a*) The ring disease of potatoes.

(*b*) Organisms capable of destroying Amsacta caterpillar were isolated and field scale inoculation conducted.

(*c*) The possibilities of controlling Fusarium wilt in paddy by saprophytes like Aspergillus niger were studied.

(*d*) Cultures of bacteria capable of extracting oil from oilseeds were isolated.

(*e*) Study of the retting of coconut fibre.

15. *Activated sludge plant.*—When the activated sludge plant was first set up frequent inspections and examination of the effluent, etc., were made to ensure its efficient working.

Field experiments to determine the manurial value of the sludge and effluent were conducted. It was found necessary to dilute the effluent with twice its volume of irrigation water to avoid scorching effect on paddy.

CHAPTER 21.

SYSTEMATIC AND ECONOMIC BOTANY.

Early History—The Madras Herbarium—Botanical surveys—Madras flora—Life history of herbarium crop plants—Seed collections—Taxonomic research—Exchange of specimens with foreign countries—The College Botanic Garden—Economic Botany—Seed testing—Plant identification—List of new species identified.

Introduction.—The Botany Section is one of the oldest in the Department of Agriculture and may, in fact, be termed as the mother of all the other sections, like the Paddy Section, the Cotton, the Millets, the Pulses and the Oilseeds. It had its beginnings in the Board of Revenue and came under the Agricultural Department in 1902, when Dr. C. A. Barber was put in charge as the Government Botanist. In 1912, Dr. Barber was appointed as the Sugarcane Expert and the Botany Section got bifurcated into two, one under the Government Economic Botanist for the improvement of crops like rice, cotton, etc., and the other under the Government Lecturing Botanist for teaching Botany to the students of the Agricultural College. The Economic Botanists' Section was in due course, again split up into separate sections for each of the various crops like rice, cotton, millets and pulses, when the need arose for devoting individual attention to the improvements of these crops. In the Lecturing Botanist's Section, various changes of designation and control took place, till in 1942 it came again under the control of the Government Lecturing and Systematic Botanist. This section deals at present with all aspects of plant study other than those dealt with by the different crop specialists. These studies are mostly on the systematic study and the Botanical Gardens at Coimbatore and the Madras Herbarium are under the charge of the Lecturing and Systematic Botanist.

The Madras Herbarium.—The herbarium has a history that is worth recording. It is older than the Botany Section itself and originated in 1874, through the efforts of Mr. M. A. Lowson who was then the Principal of the Presidency College, Madras, and was, a keen botanist himself. The herbarium was first located in Madras and then at Ootacamund, but as neither of these places proved entirely satisfactory for the preservation of the herbarium specimens, it was finally shifted to Coimbatore in 1909 with the opening of the newly-built Agricultural College there. The collection contains at present more than 25,000 sheets of plant specimens, most of them authenticated by the Kew Herbarium in London. It is the second largest collection in India, the first being the one at the Sibpur Gardens in Calcutta and serves as

a very useful clearing house of botanical information for the whole of South India. The collection represents mainly the South Indian flora, though foreign specimens from countries like Ceylon, Australia and even America are also received from time to time by way of exchange for Indian specimens sent to these countries.

Plant identification forms naturally, the major item of work in the Herbarium and about 1,000 specimens are identified every year for various colleges and for private individuals. About 800 new specimens are also added every year.

Botanical surveys.—An ecological survey was carried out in 1946 under post-war development schemes in three districts, Anantapur, Guntur and Coimbatore, to explore the possibilities of utilizing the waste lands in these districts, after a study of the plant associations in these areas. Hindupur taluk in the district of Ananatapur, was found to have the largest area of cultivable waste lands and the area was eminently suitable for cultivation, if only a supply of water was made available by sinking wells in suitable places.

Systematic surveys and floras.—Botanic surveys have been carried out from time to time by this section from the early years for collecting and studying the flora of different districts and of certain special areas like, for instance, the high range evergreen forests of the Kunnikatti hills in Tirunelveli district at an elevation of 6,000 feet above sea level. The floras of Tirunelveli and Ramanathapuram are now completed and await publication. An ecological survey of plants growing in the black soil areas of Madras State was made in 1930. Apart from adding knowledge on the systematic side, these surveys have also yielded information of practical importance as can be gathered from the following instance :—

Krusadi.—This is a small is land near the famous shrine of Rameswaram which is unique in having a type of vegetation that is entirely different from the mainland at Rameswaram and Pamban. This island was surveyed very thoroughly and its flora has been written up with special reference to the ecological aspects. As a result of this survey, some potentially valuable grasses and forage plants suitable for saline areas, have also been secured, such as *Sporobolus tremulus* Kunth, *S. orientalis* Kunth and *Atriplex* species. A similar survey of the flora of the chain of small islands adjoining Krusadi island in the Gulf of Mannar has also been taken up and is nearing completion. A botanical survey of the " back-water " areas on the West Coast, resulted in the discovery of some plants that are suitable for green manure, namely *Rhizophora mucronata* Lam., etc.

It may be recorded in this connection that the material from which the flora of the Madras State was written up by Dr. J. S. Gamble, was supplied mainly from the Madras Herbarium at Coimbatore. A beginning had been made in 1912 on this work and the first volume of the flora was published in 1915 when

Dr. Gamble was requested by the Government of India to undertake the task of completing this work. The several parts of the flora were published one by one and the seventh and last volume was brought out in 1925, after Dr. Gamble's death, by Mr. C. E. C. Ficscher, of the Indian Forest Service and the completed work was published in July 1935 as a worthy memorial to the strenuous labours of a distinguished botanist.

' Life-history ' Herbarium of crop plants.—As no herbarium in an Agricultural Institution can be considered complete without a representative collection of agricultural crops at all stages from seed to seed, a life history herbarium was prepared in 1929–30. About 880 specimens representing 65 species of crop plants have been collected at different stages of growth, with full notes on the size, shape and other characteristic features of the plants at each stage, its manurial and water requirements and similar relevant information recorded for each species.

Seed collection.—In addition to the main specimen sheets in the Herbarium, there is also a collection of seeds of most of the plants of Madras, arranged according to Gamble's Flora. This collection facilitates the identification of plants in the absence of complete specimens with floral organs, as often the fruits or seeds alone are received for identification and the seed collection in the Herbarium makes it possible to identify the parent plants from the fruit or seed material that is available.

Economic Herbarium.—Although the Herbarium is fully representative of the flora of Madras, still there are many exotic species of plants that are of economic importance which do not find a place in the general collection. To facilitate ready reference, different economic groups such as cereals, pulses, oilseeds, vegetables, green manures, forage plants, weeds, poisonous and medicinal plants, have been classified separately with full descriptions for each specimen sheet. This collection of economic plants is found to be of very great interest to all visitors and as such seems to meet a real need.

Taxonomic Research.—The systematic position of nearly 100 new species of plants has been studied and described by veteran workers like K. Rangachari, C. Tadulingam and K. C. Jacob. A list of such new species will be found in Statement I at the end of this chapter. More recently, in 1944–47, a study has been made on the morphological characters of cucurbit varieties collected from Tanjore, Malabar and Godavari districts among which one variety known by the name of *Vellarimathan* from Malabar proved to be a distinct species, *Cucurbita maxima* Duch, and different from the great majority of the cultivated pumpkins of South India which belong to the species *Cucurbita moschata* Duch. Seeds obtained from an interspecific cross betwen *C. moschata* Duch and *C. maxima* Duch were found to be not viable and colchicine treatment for inducing fertility through

polyploidy was also not successful. In the course of the study, however, a new variety *Cucurbita maxima* var. *Badagarensis* has been distinguished and described.

A good deal of the confusion that had existed between *Acacia* species, such as, for instance, between *Acacia alba* Willd and *A. leucophloea* Willd has been now clarified. No tomentose pods occur in *A. leucophloea* Willd as they do in *A. alba* Willd and the two species are found in well-defined regions without any intermediate forms.

Exchange of specimens and information with foreign countries.—The exchange of botanical knowledge from one herbarium to another is helpful, both for internal development and external recognition. A beginning was made in this direction in 1929, by entering into an agreement with Canada, California, South Africa, Egypt, Russia, the Phillippines, Singapore and Scandinavia and specimens are being exchanged with these countries regularly.

Botanic gardens.—The Botanical Garden attached to the Agricultural College, Coimbatore, was started in 1908 with the object of demonstrating to students the methods of maintaining ornamental gardens. There are nearly 300 species of various trees, shrubs and climbers in the garden at present, with a rockery and a green house for xerophytes and ferns. New plants are also introduced from time to time. The sale of seeds and seedlings of ornamental plants formed a major part of the revenue derived from the Botanic Garden.

Economic Botany.—In view of the confused state in which the classification of banana varieties exists at present, where the same variety is often known by different names in different places, a systematic survey was taken up in 1930, and all available varieties collected from all over the State. These were planted and studied at Coimbatore as a result of which it was possible to reduce the 500 forms that were collected to 74 distinct varieties. Full descriptions of these have been recorded from the time of planting up to the harvest stage and written up as a monograph for publication. A series of popular notes have also been published from time to time on the cultivation of bananas in different regions of Madras and other areas like Travancore and Mysore.

Green manure and cover crops.—In the course of the systematic and ecological tours that were carried out by the Botany Section, it was also the practice to enquire for new types of plants that might prove useful as green manure crops, collect seeds and grow them at Coimbatore for observation. Of these, *Cassia nigricans* vahl, collected from Tirunelveli district was found promising. Another plant, *Tithonia diversifolia* A, Gray (*compositæ*) was also found promising in the sandy areas near Mangalore. Trials were conducted with *Kudzu vine* (*Pueraria hirsuta*, Scheid Benth and Tropical Kudzu (*Pueraria phaseoloides* Benth at Coimbatore and other centres like Ootacamund, Kallar and Burliar on the Nilgiris. *P. hirsuta* proved a failure but

P. Phaseoloides was found to thrive in rainy localities like Mangalore and Malabar. *Phaseolus sub-lobatus* Roxb, a leguminous forage and green manure crop, was found to grow very well in Godavari delta, South Arcot and Tiruchirappalli.

Cucumis pubescens Willd.—This is a plant that is found in Salem and in East Coast districts in which the nomenclature was somewhat confused. Roxburgh (1832) had described this plant as *Cucumis madraspatanus* Roxb, which the Index Kewensis (1895) cited incorrectly as *C. melo*, which is the common water melon. A note clarifying the nomenclature and describing the economic uses of this plant was published in 1941.

Land reclamation and soil conservation.—A number of swampy and saline areas exist in the State which can be reclaimed in course of time provided suitable plants are made to grow there. The grass *Brachiaria mutica* Stapf, was found to be very useful for reclaiming marshy areas in addition to being a very good fodder grass. Similarly saline tracts, where nothing else will grow, can be turned into grassland by growing species like *Chloris barbata* Sw., *Chloris Bournei Rang. et. Tad. and Sporobolus tremulus*, Kunth. Other species like *Pennisetum hohenackeri*, Hochst, *Cynodon plectostachyum*, Pilger, are very useful as soil binders, in the control of soil erosion. *Clerodendron inerme*, Gaertn. prevents soil erosion effectively on sea-shores.

Wild edible fruits.—As useful additions to the list of common and usually expensive fruits like oranges, mangoes and apples, etc., a survey of wild fruits was made in 1940 and a list of 68 plants, where the fruits are edible, was published.

Seed testing.—Numerous seed samples are received for testing their viability and this forms one of the items of work whereby the Botany Section is of service to the Department as well as the general public.

Exotic plants.—Though plants from other regions and countries are being introduced ever since the section was opened, a specific scheme was started in 1947 to test new introductions in selected areas of different rainfall and altitudes. Four stations, Anakapalli and Aduthurai on the plains and Ootacamund in the hills with medium rainfall and Wynaad with heavy rainfall were selected. About 25 species were tried of which the following have been found promising :—

(1) *Ochroma lagopus*, Sw. Balsa or Aeroplane wood for floats, buoys, and aeroplane frames.

(2) *Salix* species for cricket bats.

(3) Ramie (*Boehmeria nivea* HK. & A). This Urticaceous plant yields a very strong fibre.

(4) *Geraniums* for perfume-making essential oils.

(5) *Mentha piperata*, Linn, for menthol extraction.

***Research.*—Among the research problems that have been taken up for investigation in the Botany Section may be mentioned**

the following: (1) Stomatal distribution in cotton flowers. Stomata have been observed on bracts, calyx, anthers, epidermis of the ovary, styles and even on the non-bearing portion of the stigma. In the green parts of the flower, viz., the bracts and calyx and the epidermis of the ovary, the stomata were functional just as in the leaves (1923). (2) Pollen sterility in relation to vegetative propagation. In the process of cultivation, vegetative methods of propagation have been evolved for a number of plant species and this has been found to give rise to pollen sterility, which is observed to be rather a regular feature in plants that are as a rule, propogated only vegetatively, as for example in *Thespesia populnea* Cav. (3) Bud and boll shedding in cotton. A preliminary attempt was made as early as 1923 to unravel the nature of this shedding of buds and bolls in cotton. (4) The spike disease of sandal was another problem that was investigated as early as 1924. It was shown that the disease is a physiological disorder brought about by an unfavourable host-parasite relationship leading in water deficiency in the parasitic sandal plant.

A list of books and other publications emanating from the Botany Section is furnished in Statement 2.

Statement 1.

List of New species from the Botany Section.

1 Aerides ringens, C. Fisch.
2 Agrostis schmidii, C. Fisch.
3 Amphilophis foulkesii, C. Fisch.
4 Amphilophis pseudoischeaemum, C. Fisch.
5 Arisaema barnesii, C. Fisch.
6 Arisaema tuberculatum, C. Fisch.
7 Arisaema tortuosum schott, var. neglectum, C. Fisch.
8 Arisaema translucens, C. Fisch.
9 Arisaema tuberculatum, C. Fisch.
10 Arisaema tylophorum, C. Fisch.
11 Arthraxon villosus, C. Fisch.
12 Arundinella setosa, Trin, var. lanifera, C. Fisch.
13 Ascopholis gamblei, C. Fisch.
14 Avenastrum asperum, C. Fisch.
15 Actinodaphne tadulingami, Gamb.
16 Belosynapsis epiphytica, C. Fisch.
17 Belosynapsis vivipara, C. Fisch.
18 Biophytum longibracteatum, Tad & Jac.
19 Bulbostylis puberula Kunth, var. graciles, C. Fisch.
20 Caralluma stalagmifera, C. Fisch.
21 Carex lindleyana, Nees var major, C. Fisch.
22 Carex lindleyana Nees var mercarensis, C. Fisch.
23 Centratherum rangacharii, Gamb.
24 Chionachne semiteres, C. Fisch.
25 Chloris bournei, Rang & Tad.
26 Chrysopogon hackelii, C. Fisch.
27 Coelachne meeboldii, C. Fisch.
28 Coleus vertiveroides, K. C. Jacob.
29 Commelina jacobii, C. Fisch.
30 Cryptocoryne ciliata, Fisch.
31 Cryptocoryne spiralis, Fisch.
32 Cynodon barberi, Rang & Tad.
32A Cucurbita maxima, Duch, var. badagarensis, Mudarliar, C. R.
33 Cynodon dactylon Pers. var. intermedius, C. Fisch.

34 Dendrobium aphyllum, C. Fisch.
35 Dimeria avenacea, C. Fisch.
36 Dimeria bialata, C. Fisch.
37 Dimeria lawsoni, C. Fisch.
38 Dimeria karumthotticalana, K. C. Jacob.
39 Dimeria kanjirapallilana, K. C. Jacob.
40 Disporum leschenaultianum D. don var. angustifolium, C. Fisch.
41 Eleocharis chaetaria R. & S. var. sub-vivipara, C. Fisch.
42 Eragrostis diarrhena Stand var, Koenigii, C. Fisch.
43 Eriocaulon conicum, C. Fisch.
44 Eriocaulon ensiforme, C. Fisch.
45 Eriocaulon gamblei, C. Fisch.
46 Eriochrysis rangacharii, C. Fisch.
47 Eulophia cullenii, C. Fisch.
48 Eulophia epidendraea, C. Fisch.
49 Ficus angladei, C. Fisch.
50 Fimbristylis aggregata, C. Fisch.
51 Fimbristylis bisumbellata Buf var, hirtistyla, C. Fisch.
52 Fimbristylis contorta, C. Fisch.
53 Fimbristylis dichotoma vahl. var. villosa, C. Fisch.
54 Fimbristylis narayanii, C. Fisch.
55 Fuirena pubescens Kunth var. pergamentacea, C. Fisch.
56 Habenaria digitata, var. gibsoni, C. Fisch.
57 Habenaria digitata Lindl. var. travancorica, C. Fisch.
58 Hopea jocobi, C. Fisch.
59 Impatiens aliciae, C. Fisch.
60 Impatiens anaimudica, C. Fisch.
61 Impatiens neo-barnesii, C. Fisch.
62 Impatiens coelotropis, C. Fisch.
63 Impatiens dendricola, C. Fisch.
64 Impatiens laticornis, C. Fisch.
65 Impatiens neo-barnesii, C. Fisch.
66 Impatiens nilgirica, C. Fisch.
67 Impatiens platyadena, C. Fisch
68 Isachne angladei, C. Fisch.
69 Isachne bourneorum, C. Fisch.
70 Isachne meeboldii, C. Fisch.
71 Isachne setosa, C. Fisch.
72 Ischaemum rangacharianum, C. Fisch
73 Ischaemum timorense, Kunth. var, villosum, C. Fisch.
74 Lagenandra meeboldii, C. Fisch.
75 Manisuris acuminata, C. Fisch.
76 Manisuris forficulata, C. Fisch.
77 Melanocenchris monoica, C. Fisch.
78 Microstylis densiflora, C. Fisch.
79 Ochlandra scriptoria, C. Fisch.
80 Ochlandra wightii, C. Fisch.
81 Pavonia coxii, Tad & Jac.
82 Pilea kingii, C. Fisch.
83 Pouzolzia wightii, Benn. var, caudata, C. Fisch.
84 Pouzolzia wightii Benn. var, lawsoniana, C. Fisch.
85 Pouzolzia wightii Benn. var, scabra, c. Fisch.
86 Rhynchostylis latifolia, C. Fisch.
87 Saccolabium pulchellum, C. Fisch.
88 Scirpus jacobi, C. Fisch.
89 Senecio ansteadi, Tad & Jac.
90 Sida beddomii, K. C. Jacob.
91 Sonchus nemakadensis, C. Fisch.
92 Sonchus tinnevelliensis, C. Fisch.
93 Sorghum stapfii, C. Fisch.
94 Teinostachyum beddomei, C. Fisch.
95 Tripogon pungeens, C. Fisch.

PART III

CHAPTER 22

CROP PESTS.

The growth of economic Entomology—Life history and methods of control of pests of the following crops :—Rice, Sorghum, Ragi, Pulses, Vegetables, Fruits, Sugarcane, Cotton, Coconut, Groundnut, Castor, Betelvine, Agathi, Tobacco, Coffee, Pepper, Cardamom, Pests of stored products—Cattle and household pests—Biological method of control—The prickly-pear cochineal—Indigenous insecticides—Eel worms—Pest control methods—Preventive and curative aspects —Mechanical, chemical and biological methods—Parasites—Precautions in the use of insecticides—Legislation—The several pest Acts—Plant quarantine regulations—List of crops, their Pests and methods of control.

Introduction.—Research in the field of economic entomology was first initiated in this State during the year 1906 on a modest scale with a staff of one Assistant, who worked under the control of the Government Botanist. The pioneer work was so full of promise that the organization of a separate branch was very soon contemplated and the proposals bore fruit before long in the shape of an independent section by 1912 under the Government Entomologist. The main object of this organization was to make a comprehensive study of the insect problems of this State and devise suitable methods of control. The first few years had necessarily to be devoted to a general survey of the insect fauna of South India with special attention to the economic forms, the building up of a representative reference collection, the study of their life-history and habits and devising suitable methods of control, wherever possible.

While the importance of the basic knowledge accrued during this period cannot be over-estimated, the practical solution of the various insect problems proved to be altogether a different matter. The suddenness of outbreak of the pests along with their incidence in out of the way orners of the State and the rapidity with which damage was done rendered progress necessarily slow. The localities had to be visited year after year and guided by the gradually accumulating experience, control methods mostly of a mechanical nature, were devised and tried. The section also kept itself abreast with the development and expansion of plant protection work in other countries and the use of arsenical poisons and contact insecticides slowly came into vogue. Along with the evolution of control methods, their actual transmission to the ryots was also kept in sight. In cases where such methods had to be practised on a vast field-scale, the aid of the Pest and Diseases Act which

was introduced in 1919 was also invoked. The subsequent line of activity, initiated probably for the first time in this country was the study and exploitation of beneficial insects like parasites and predators for the biological control of crop pests and considerable progress has been made in this line. Another outstanding achievement was the contribution made towards the development of Bee-keeping as a flourishing and popular cottage industry in South India as we find it to-day.

With the outbreak of the World War II by 1939 and the consequent non-availability of imported insecticides, attention was diverted to the possibilities of using some of the indigenous vegetable poisons against insects and the high insecticidal potentialities of some of these drugs came to light. And almost in the wake of the successful termination of the war, the country was faced with a serious food deficit. The Government had, therefore, to adopt a policy of stocking enormous quantities of foodgrains either procured locally or imported from abroad and hold them in reserve to ensure a regulated supply to the public. The evolution of efficient methods of conservation of the foodgrains against ravages of their special insect pests is one of the major contributions of the section towards solving the present food problem in the country.

In recent times, the availability and adoption of the two new wonder insecticides—DDT and BHC—have practically revolutionized plant protection in the State. The chemicals produced spectacular effects against many a pest, control methods for which were either imperfect or non-existent so far. At the present rate of development, there is reason to hope that the control of crop pests would soon cease to be a serious problem. The recent organization of a separate Plant Protection Service during 1949 came in as a happy coincidence with the above developments and has given the necessary fillip to the active popularisation of the control methods among the ryots. The system of supplying the chemicals at subsidised rates for food crops has served as a further incentive to the ready adoption of the departmental advice on a scale unprecedented in the annals of the department. Findings of interest, either in the systematic or economic aspect, have been published from time to time in short papers of which the section can claim about 300. The following are the important insect pests found in Madras State in the order of crops which they infest :—

1. Rice.

The swarming caterpillar of rice (Spodoptera mauritia, *B.*).—This is one of the most serious pests of rice occurring throughout the Oriental and Australian regions. In South India, it is prevalent in almost all the rice-growing areas but is chronic in parts of the West Coast and the Northern Circars. (Plate 110.)

Reports about the incidence of the pest are on record from the very inception of the section. In earlier years a detailed study

Plate 110. 1. *The swarming caterpillar of paddy* — Spodoptera mauritia, *B.*

P. 909

of the life history and habits of the pest was made. The caterpillars appear in swarams invariably on the seed-bed and occasionally on the transplanted crop as well. The female lays hundreds of eggs in small masses on wild grass and rice plants and covers them with a layer of buff-coloured hairs. The caterpillars hatch out in three or four days and usually escape notice. They feed on the crop mostly during nights and the damage itself is noticeable only at the time when the caterpillars attain full growth and are most destructive. The larvae get mature in about 20 or 25 days and pupate under the soil from which the adult emerges in the course of 10 or 15 days. The pest is kept under check to a certain extent in nature by a few hymenopterous parasites like *Charops dominans*, W., *Apanteles reficrus*, Hal., *Chelonus Sp.*, *Euplectrus uplexiæ* Roh., and dipterous parasites such as *Cyphocera varia*, F , *Sturmia bimaculata*, H., *Tachina fallax*, M., *Actia ægyptia*, V., and *Pseudogonia cinerascens*, R. Besides the common duck, a number of other birds are also known to feed on the caterpillars among which may be mentioned the common crow, *Corvus splendens*, V., the jungle crow, *Corvus macrorhynchus*, W., the cattle Egret (*Bubulcus ibis*, L.), the paddy bird *Ardeola grayu*, S., the white breasted water-hen (*Amaurornis phœnicurus*, P.), and the common mynah (*Acidotheres tristis*, L.). In some cases a bacterial disease has been found to set in on the grown up caterpillars and decimate them.

Alternative host plants.—Besides on rice, the pest has also been found to breed on a variety of hill grasses like *Panicum setigerum*, *P. javanicum*, etc., in parts of Malabar, Palur and Hosur. The caterpillars have also been noted to feed on barley, wheat and maize in other parts of India.

Control.—One of the methods of control advocated till recently was flooding the infested fields with water, which may be practicable only in the case of nurseries. The caterpillars are forced to come out of their hiding places and collect themselves on the top portions of the plant, from where they can be either swept or collected and killed. Letting in ducks, where they are available, has been found to afford a definite relief. The dispersal of the caterpillars to uninfested areas is prevented by digging trenches right around. Trials with arsenical poisons like Paris green, calcium and lead arsenates, etc., have met with only partial success.

Recently, dusting with BHC D·025 at the rate of 20 lb. per acre appears to have practically revolutionized the crude methods in vogue and large quantities of the chemical are now being used by cultivators for the control of the pest. The cost of treatment is Rs. 7 or Rs. 8 per acre.

The rice grasshopper (Hieroglyphus banian Fabr).—This is another serious pest, which has been engaging the attention of the section ever since 1912. There is also evidence to show that the serious nature of these hoppers have been felt as long ago as 1890.

Two distinct species are concerned in the damage but the major one is *Hieroglyphus banian*, Fabr. It has been noted in almost all the rice growing areas of this State but its annual occurrence is restricted to parts of Malabor and Northern Circars. The life-history of the pest is briefly as follows : The adult inserts her eggs in small masses under the soil at a depth of two to four inches during October-November. These egg-masses are enclosed within a membranous sheath so as to protect them from the adverse effects of moisture and heat. The eggs remain under the soil till the next summer. The embryonic development commences with the onset of the first summer showers and the nymphs hatch out with the outbreak of the monsoon during June-July. They first feed on the grasses growing on the bunds and subsequently transfer their activities to the transplanted crop. The more destructive stage is reached by October, when the crop is in shot-blade. Most of the nymphs develop into adults by this time and they have the peculiar habit of cutting down the side leaves and also gnawing at the base of the flag-leaf. The injury thus caused cuts off the supply of nutrition to the developing ears as a result of which they are either unable to come out or get distorted in shape. The adults, after causing enough injury, mate and oviposit on the nearest bund and perish. There appears to be only one brood during a season. In severe years, the loss may be as high as 75 per cent but the average will be somewhere about 10—15 per cent in the infested areas. (Plate 111.)

Alternative host plants.—The pest also occasionally occurs on sugarcane and millets on a serious scale. The nymps feed on a variety of grasses growing on the bunds in paddy fields.

Natural enemies.—The following natural enemies have been recorded to attack this pest. A few birds such as the Indian Roller (*Coracias benghalensis*, L.), the Brahminy Kite (*Haliastur indus*, B.), the Pariah kite (*Milvus migrans*, B.), the comon crow (*Corvus splendens*, V.), the mynah (*Acridotheres tristis*, L.) and the King crow (*Dicrurus macrocercus*, V) have been found preying on the hoppers. Certain species of the frog—*Rana*, the common water snake—*Tropidonotus piscator* and jackals also form some of the other vertebrate predators of this pest. Grubs of the blister beetle —*Mylabris pustulata* T. have been noted (1915) to feed on the egg capsules. Parasitisation by *Scelio* sp. (Scelionidae) is a solitary instance of beneficial activity by Hymenopterans in this case. Two species of Nematodes *Gordius* sp and *Mermis nigrescens*, D. infest the pest and are found to inhibit the reproductive activity of both the sexes. In parts of Circars instances of dead hoppers infested by a species of fungus have been recorded. These were found dead and firmly attached to rice stalks by mycelial threads, especially after the rains. A small reddish mite, probably *Trombidium* sp. causes a certain amount of mortality among the adults. In spite of the vast array of natural enemies, even their cumulative effect has at no time been known to appreciably reduce the severity of damage

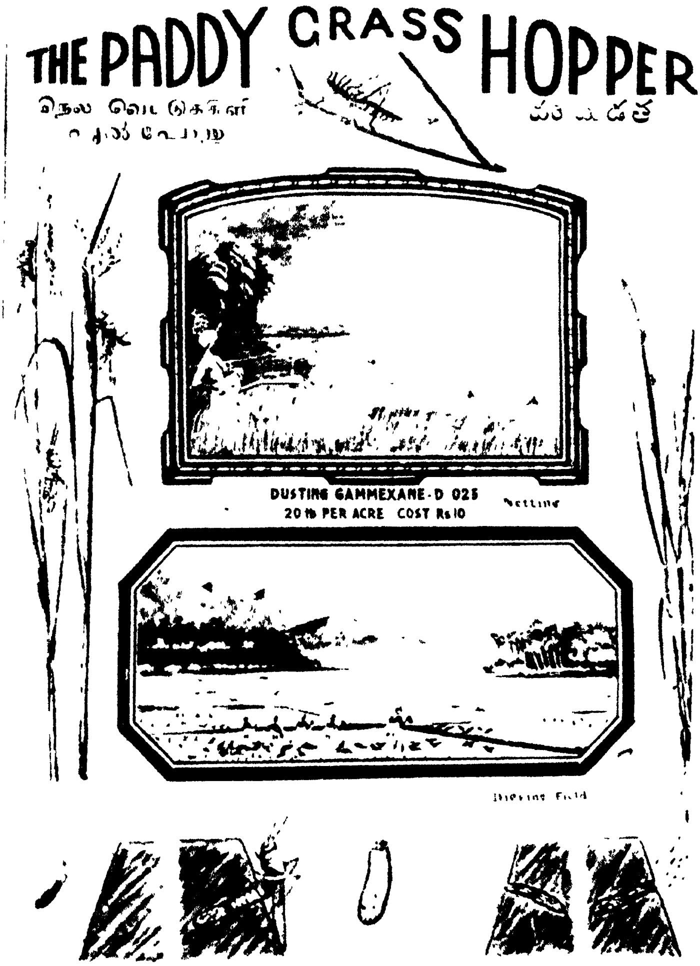


Plate III.—*The paddy grasshopper* Hieroglyphus banian, *F.* P 913

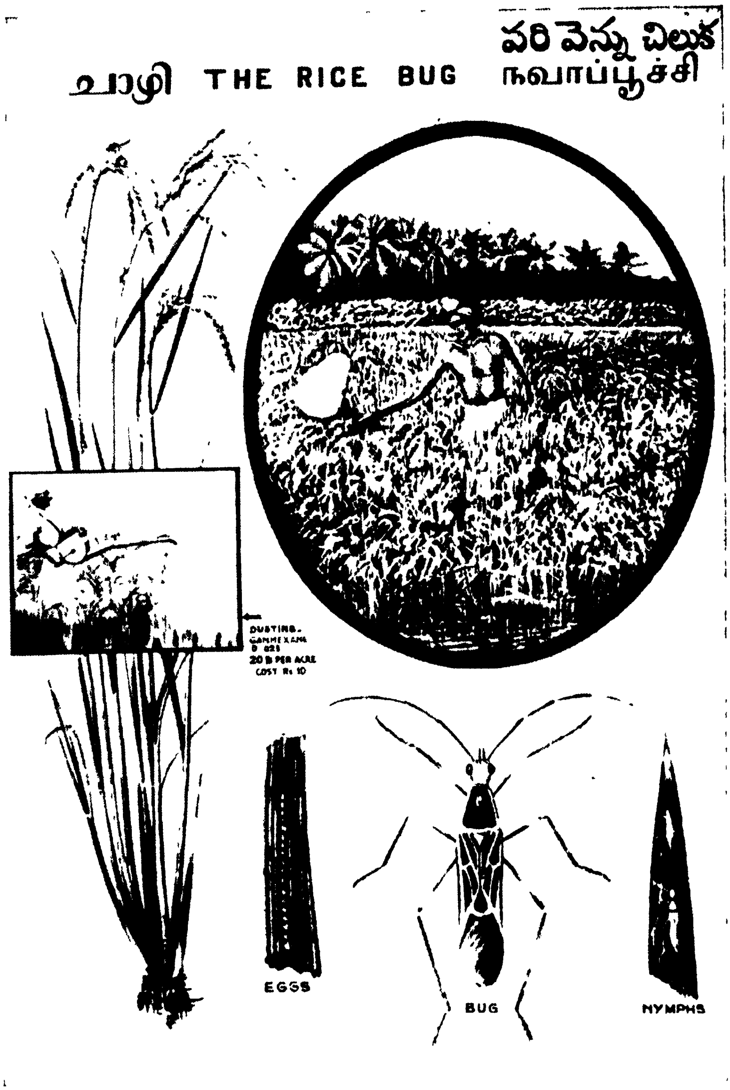


Plate 112.—*The rice bug* Leptocorisa acuta, *T*. P 914

caused by the hoppers. Mechanical methods of control like the use of hand-nets against the nymphs feeding on the bunds were first tried. In some localities, the hoppers are carefully driven to a convenient corner of the fields, where a temporary screen is improvised and are subsequently beaten to death. These crude and laborious methods failed to create any impression on the ryots. Trials with arsenical poison baits and sprays were equally futile. A more rational method of scraping the bunds immediately after harvest, when they are moist, with the object of cutting and exposing the egg-masses, was demonstrated on a large scale during 1927–28 but the results were not at all impressive. BHC dust even at a low concentration of 2 per cent was found capable of causing the entire annihilation of the pest. Twenty pounds of the standard concentration BHC D.025 costing Rs 7 to 8 are required to treat an acre and its use has since become exceedingly popular in areas where the incidence is chronic.

The rice bug (Leptocorisa acuta, *T*).—This is another pest which has been under investigation from the year 1912 onwards. The adult is a fairly big-sized greenish-yellow insect with long legs and possessing a peculiar buggy odour. It has a wide distribution in the State but is very severe in parts of Coimbatore and the West Coast The bugs appear in swarms on the rice ear-heads at the milky stage and suck up the juice from the tender grains. The attacked grains become chaffy and the loss is sometimes serious. The bugs are not capable of causing any damage after the grain have set and hardened. (Plate 112.)

The female lays her brownish seed-like eggs in rows of 10 to 20 on the leaf blade. The slender nymphs hatch out in about a week and begin to feed straightaway. They develop into adults in about a fortnight. The bugs feed on a number of wild grasses during the off-season. A tiger beetle *Cicindela sexpunctata*, L., has been found to be predatory on these bugs.

Control.—The period of infestation being short, a systematic hand-netting and destruction of the bugs was found quite efficient. An acre can be covered by four or five men in the course of two or three mornings and as such the cost would be within the reach of the average ryot. Recent advancement in the control methods consists of the use of BHC D.025. The chemical even at a low strength of 2 per cent has been found to exterminate the pest in the course of a few hours and the method has passed the experimental stage. About 20 lb. of the dust costing Rs. 7 or Rs. 8 may be required for an acre.

The climbing cutworm of rice (Cirphis albistigma, *M.*).—This is a serious pest of fodder grass, but appears in destructive proportions on rice during certain years. Similar to the swarming caterpillar in general features and habits, it has been recorded from the Coromandel and western tracts as well as some central districts

of this State, though not in as serious a form as Spodoptera. On rice the pest usually makes its appearance in January-February, May and October.

The adult is a dark-brown stout insect, the male being provided with a more prominent tuft of hairs at the tip of the abdomen. The female lays her eggs usually within leaf sheaths, leaf folds, etc. The caterpillars hatch out in four to five days and pass through a series of moults before pupation. They are soft bodied, smooth, cylindrical and short, appearing in swarms and climb the plant and cut off the earheads. The average life cycle from egg to adult lasts for about 32 to 43 days.

A number of natural enemies have been observed to take their toll of the pest. These include crows, ants, some Tachinid parasites like *Actia manticola*, M., *Cyphocera*, F., and *Sturmia inconspicuoides*, B., the Braconid *Meteorus* sp. and the Ichneumonid *Xanthopimpla* sp.

Control.—Trials with Paris green, calcium arsenate, poison-baits, light traps, etc., proved of no avail. Mechanical measures like collection and destruction are impracticable. The latest method is dusting BHC D.025 dust as in the case of the army worm and this is being popularized with a remarkable degree of success.

The Rice Hispa (Hispa armigera, *Ol.*).—This is a small bluish black beetle provided with a series of short spines all over the body. It has been reported from the West Coast, Salem, North Arcot and the Circars from the year 1915 onwards. Only young crops and nurseries are subject to the attack of this pest and both the adults and the young ones are responsible for the damage. (Plate 113.)

The life-history of the pest is briefly as follows: The eggs are inserted between the upper and lower surface of the young leaves near the tip, and the grubs on hatching burrow into the tissue and feed on the green matter. The attack is invariably characterised by the blistered patches on the leaf-tips. The grubs pupate in the same burrows. The adults also feed on the plant and their damage is characterised by the parallel white streaks of the leaf surface. The control measures tried and advocated so far lay in hand-netting the adults as well as clipping the tips of the affected plants. Spraying with the then available stomach poisons has been reported effective though somewhat costly. Recently dusting with BHC D.025 at the rate of 20 lb. per acre has given very convincing results.

The spotted rice jassid (Nephotettix bipunctatus, *F*).—These are small active wedge-shaped insects, about 5 mm. in length, green in colour and the males have two prominent black spots on the forewings. The bugs have not been recorded on a serious form till recently in this State but it was notorious as a bad pest in Madhya Pradesh, Bihar and Orissa from 1919. The pest flared up suddenly

Plate 113.—*The spotted jassid*—Nephotettix bipunctatus, *F.* P. 917

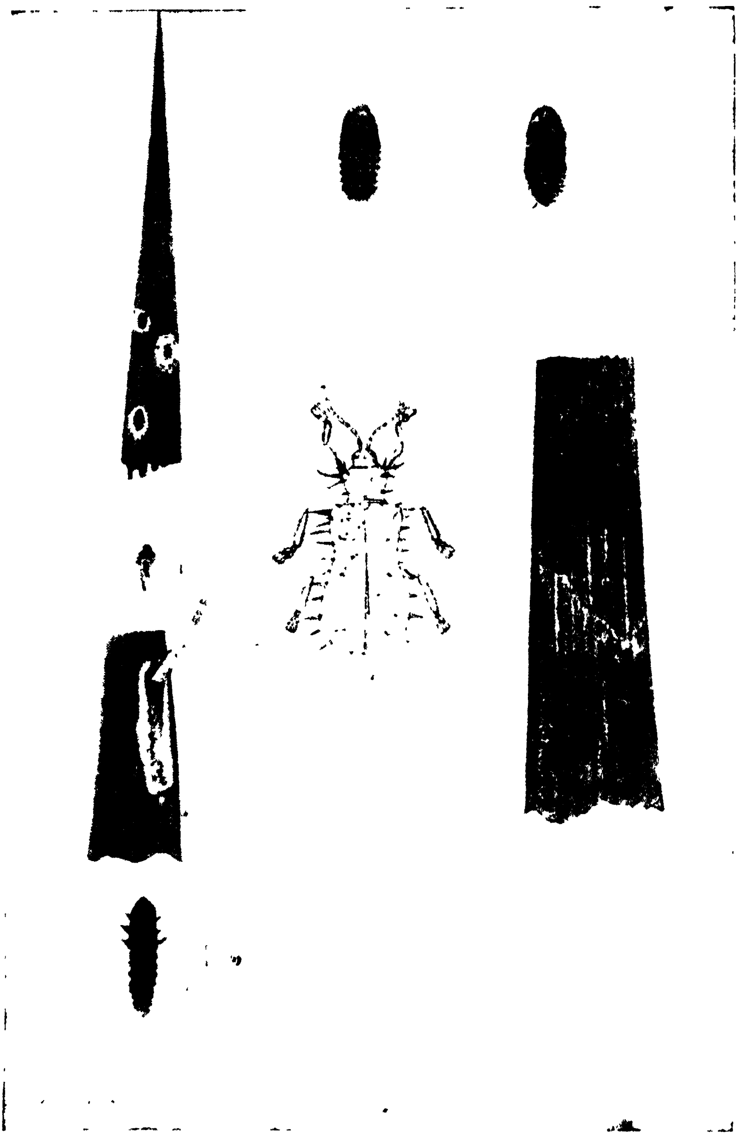


Plate 114.—*The rice hispa*—Hispa armigera, *Ol.* P. 915

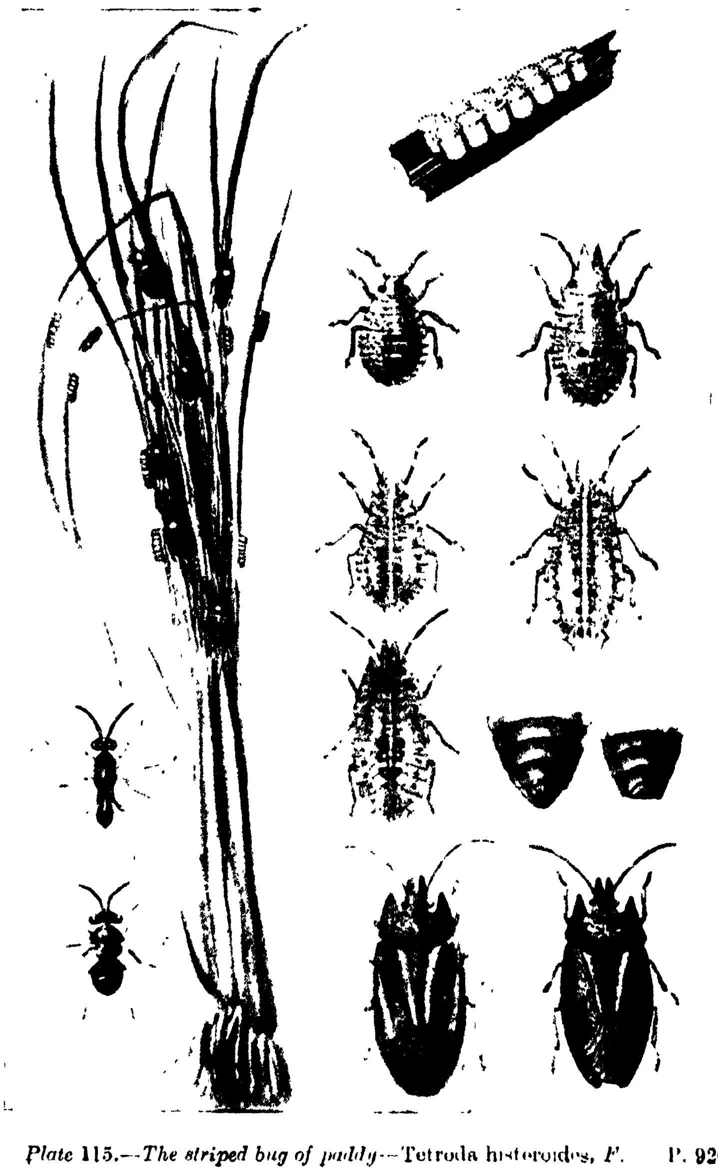


Plate 115.—*The striped bug of paddy*—Tetroda histeroides, *F*. P. 920

during 1946 in parts of North Arcot and assumed more serious proportions during 1948 devastating vast areas in parts of Tanjore, Tiruchirappalli, Salem, South and North Arcot, Madurai, Tirunelveli, Coimbatore and Chittoor. But the extreme severity of the incidence was restricted mostly to tracts where rice is grown under well-irrigation and the damage itself was confined to young crops about one or two months old. Scores of the bugs can be seen resting on the plants and the crop ultimately withers away as a result of the enormous drain of the cell-sap. The ryots had, in many cases, to plough up the infested fields out of sheer helplessness. (Plate 114.)

The female inserts her eggs into the lower leaf-sheath and the individual egg-laying capacity may extend from 24 to 34. The nymphs hatch out within four or five days and reach the adult stage within 20 days. They are ready for egg-laying in the course of another ten days. The bugs also breed on a few wild grasses during the off-season.

Control.—A systematic hand-netting of the bugs and setting up of light traps, to which they are attracted in their thousands, were till now advocated. In recent times, however, the use of DDT has been found very successful in controlling the pest. The chemical, applied either as dust or spray exterminates the pest within a cost of Rs. 5 to Rs. 10 per acre.

The striped bug of rice (Tetroda histeroides, *F*).—These bugs were first recorded in a serious form in Tiruchirappalli district during 1926–27 and have since become almost chronic to the area. More recent reports show that the pest has spread to parts of Coimbatore and North Arcot. The adult is fairly big-sized, dark brown with a prominent V-shaped mark on its back. The eggs are cylindrical in shape and are laid in rows along the lower surface of the leaves. The nymphs hatch out within a week and develop into adults in 40 to 50 days. The adults and nymphs generally hide in the lower portions of the plant and suck the sap. (Plate 115.)

Alternative host plants.—This bug has been found to feed occasionally on shoots of jack (*Artocarpus integrifolia*) and rarely on sugarcane also.

Natural enemies.—A Chalcid—*Anastatus colemani*—and an unidentified *Braconid* has been recorded as egg parasites.

Control.—Hand-netting as well as spraying with contact poisons like crude oil emulsion, fish oil, rosin soap, etc., were of little or no avail. The damage was so serious during certain years that there was no other alternative except to suggest a temporary cessation of growing of rice in these areas until the pest was definitely starved out. Ducks were noted to have a voracious appetite for these insects. In recent trials, BHC was found to give spectacular results against this pest, the concentration of the dust varying

according to local conditions. A lower strength of 5 per cent appears to be quite effective under dry conditions, while a 10 per cent strength is necessary when there is water stagnating in the field. There is, however, a more convincing mortality when the bugs are directly hit by BHC spray at 0·1 per cent strength. Another bug, *Scotinophora lurida*, B., which is often found in association with *Tetroda histeroides*, F., requires a similar treatment for its control.

The rice thrips (Thrips oryzae, *W.*).—This is essentially a pest of the nurseries and occasionally causes severe damage under certain conditions. Its incidence is common practically in all rice growing areas and is on record from 1925 onwards. The adults and nymphs lacerate the tender parts and suck up the plant sap causing the rolling and fading of the leaf tips. Eggs are inserted inside the tender leaves and the nymphs, on hatching, feed on the plant sap and develop wings in course of time. The pest does not appear to be serious as it invariably disappears after some sharp showers. Spraying with tobacco decoction effectively controls the pest. Recently spraying with DDT or BHC at 0·1 per cent strength has given equally convincing results. The experiments with the synthetic chemicals were conducted under a special scheme—DDT and BHC scheme—sanctioned by the Indian Council of Agricultural Research. (Plate 116.)

The lesser grasshopper of rice (Oxya velox *Fb.*).—This is a small greenish insect, with a yellow longitudinal stripe on either side. It often takes to rice, devouring the leaves and occasionally gnawing at the bases of the maturing earheads, which either dry up or break down on account of the weakening below. The habit of this insect is an interesting example, where insects show a remarkable adaptability to the environments. Under dry surroundings, the parent lays the eggs in masses in the soil, but under wet conditions, it prefers rice stubbles, grass clumps, leaf folds, etc., well above the water level. A gummy and frothy liquid is subsequently extruded, which on drying serves as a brown-coloured protective layer over the egg-masses. The egg period lasts from 15 to 41 days according to the season and the adult stage is reached after six or seven moults.

This species has also been recorded on sorghum, sugarcane and maize in company with the Rice grasshopper—*Hieroglyphus banian.*

Among natural enemies, Hymenopterous egg parasites, viz., *Scelio oxyae*, G. (*Proctotrypidae*), *Scelio* sp. (*Scelionidae*) and *Tumidiscapus oophagus*, G., *Anastatus coimbatorensis*, G., and *Aximopsis ovi*, G. (*Chalcidae*) predominate. The common mynah *Acridotheris tristis* and the Indian Wren warbler (*Prinia inornata*, S.) also feed on this insect.

Control measures.—As this is generally a minor pest flaring up into prominence occasionally, hand-netting the adults and nymphs was the only feasible remedy suggested. BHC 5 per cent has been equally effective against this pest also.

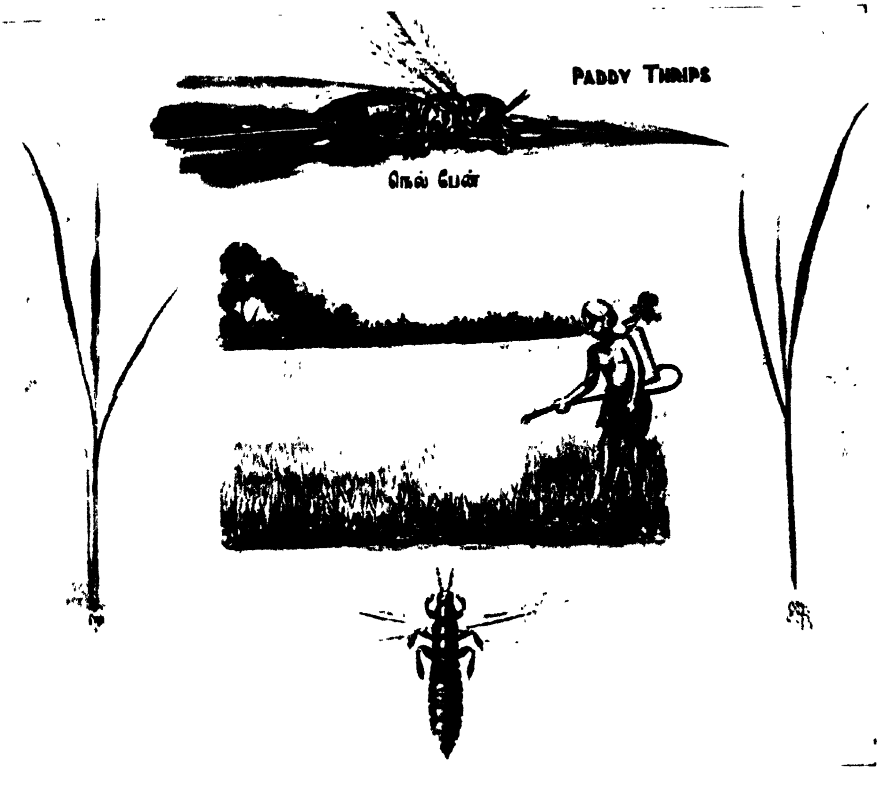


Plate 116.– *The paddy thrips*—Thrips oryzæ, W. P. 923

Plate 117.—*The paddy stem-borer*—Schœnobius incertellus, *W.*   P. 921

The rice stem-borer (Schœnobius incertellus, *W.*).—This borer is distributed in almost all the tropical and sub-tropical regions where rice is grown and considerable work has been done in China and Japan also. So far as this State is concerned, the pest has been a problem from the year 1906 in the Northern Circars, Ceded districts, Ramanathapuram, Tanjore and Malabar and still continues to be a major one. Considerable data have been gathered on various aspects like the seasons of occurrence, the main broods, natural enemies, etc. (Plate 117.)

Eggs are laid in small masses on the leaf-blade and are covered with buff-coloured hairs. The caterpillars hatch out in five or six days, bore into the central shoot and feed on the tissue. The effect of the internal damage is indicated by the withering of the central shoot in the case of young plants, while in later stages, it is evinced by the white ears. Only one caterpillar is found inside a plant and the larval stage extends from four to five weeks. Pupation takes place inside the bored tunnel and the adult emerges out in about ten days.

General observations go to show that a major emergence of the adults takes place immediately after the harvest of the first crop. The moths lay their eggs on the seedlings of the succeeding crop and their progeny infests the young plants. The next brood attacks the crop in its grown-up stage causing the characteristic white ears. While this is the general trend, there may be considerable overlapping of the broods as well. The damage is often computed to be heavy during certain years.

Natural enemies.—The following Hymenopterous parasites have been bred out of the egg and larval stages of this pest, *Amauromorpha schoenobii*, V., *Ischnojoppa luteador*, F., *Goryphus maculipennis*, C, *Tropobracon indicus*, R, *Apanteles schoenobii*, W. and *Microbracon* sp., have been recorded on the larvae while *Tetrastichus schoenobii*, F, *Trichogramma minutum*, R, *Telenomus beneficiens* have been reared out of the egg-masses.

Control.—The earliest methods tried were a systematic elimination of the egg-masses in the nurseries and a close cutting of the crop and sometimes burning and flooding of the stubbles also. These measures not being very successful, attention was later concentrated on the use of the light trap. These traps did attract large numbers of the moths, most of them gravid females and the magnitude of the catches were proportionate to the intensity of the light. The range of attraction by an ordinary hurricane lantern was about 100 yards. In spite of these interesting data, the method was not found to confer any appreciable relief. The current investigations consist of spraying BHC and DDT at the critical periods of the emergence to see whether the young caterpillars hatching out of the eggs are affected by the residual effects of the spray. The studies are in progress.

The rice caseworm (Nymphula depunctalis, *Gr.*).—The adult is a small delicate moth having white wings speckled with pale brown markings. The pest is severe on young rice crop under swampy conditions and occurs commonly in parts of West Coast. The caterpillars are slender, greenish in colour and about half an inch in length. They have the habit of cutting the leaf blades into short lengths and constructing tubular cases. They remain inside these rolls and feed on the foliage. These caterpillars are semi-aquatic in habits and are able to breathe under water.

Control measures.—The approved method is to dislodge the caterpillars from the plants by passing a rope or some thorny branches over the infested field and to drain away the water later along with the caterpillars. The addition of a small quantity of kerosene to the water has been reported to kill the caterpillars. Recently spraying with DDT has been reported to have given successful results.

The rice mealy bug (Ripersia oryzae, *Gr.*).—The insect is a mealy bug generally found in numbers inside the leaf-sheaths. The adults and the young suck up the nutrition from the plants and retard their growth. The earheads get smothered and a heavy loss is often caused. The pest is prevalent in Tiruchirappalli, Salem, Tanjore, Malabar, South Arcot and parts of Coimbatore from 1909. Eggs are laid in groups under a mealy covering and the maximum egg-laying capacity has been recorded as 319. The nymphs which hatch out from almost within a minute up to 24 hours move about for a few days and get attached to some succulent portion of the plant within the leaf-sheaths where they attach themselves more or less permanently. The nymphal period extends from 17 to 35 days. The pest has been recorded to breed on the grasses growing on the field bunds during the off-season. The young nymphs move from these grasses to the seedlings in the nursery and the infestation is inadvertantly carried to the field along with the seedlings and exhibits itself at a later stage of the crop.

Alternative host plants.—The following varieties of wild grasses serve as breeding grounds of the pest. *Andropogon annulatus, Apluda varia, Chloris barbata, Cymbopogon caesius, Cynodon dactylon, Digitaria sanguinalis, Eleusine aegyptiaca, Eragrostis interrupta, Eriochloa polystachyia, Isachne australis, Ischaemum ciliare, Iseilema laxum, Leptochloa chinensis, L. polystachyia, Panicum colonium, P. javanicum, P. prostratum, P. refens, Paspalum scrobiculatum, Saccharum spontaneum* and *Setaria glauca.* In addition to these *Cyperus rotundus, Fimbristylis argentea, F. miliacea, F. tenera* and *Juncellus pygmaeus* belonging to Cyperaceae have also been noted as alternate hosts.

Natural enemies.—A few unidentified Chalcids, ladybirds and an Agromyzid fly have been found as natural enemies of the pest but not in such numbers as to exercise any effective check on it.

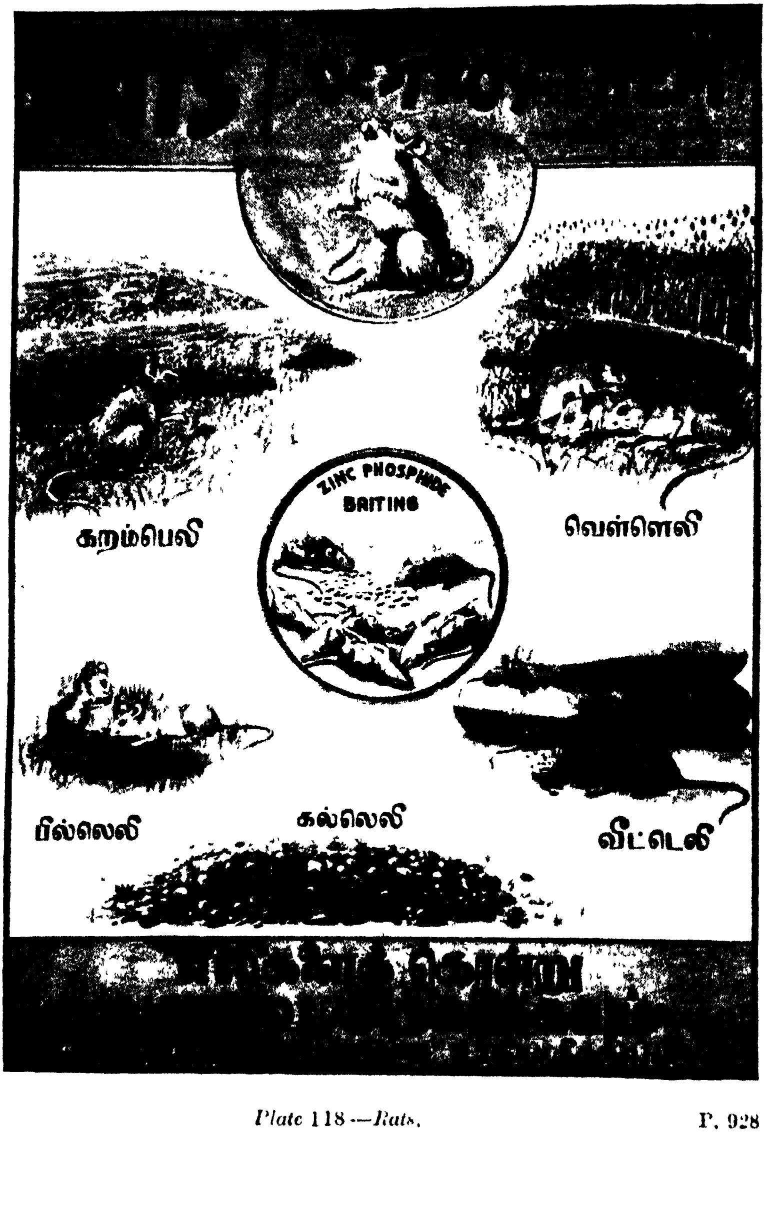


Plate 118—*Rats*.

Control.—The inaccessibility of the pest to any form of direct treatment coupled with the wide range of alternative hosts render the control of the pest a particularly difficult problem. Destruction of the infested plants was recommended as a palliative. A more rational method of scorching the bunds of the nurseries prior to sowing with the idea to eliminate the initial infestation, has been under trial from the year 1940, but the incidence of the pest has at no time been so serious as to assess the merits of the treatment correctly. Observations on the varietal susceptibility (in Tanjore) indicate that the short crop 'kuruvai' invariably escapes the damage, while the main crops of 'samba' and 'thaladi' get the worst attack of the pest. The application of DDT and BHC has not given any encouraging results. The problem is under study and a definite method of control is yet to be evolved.

The rice gall fly (Pachydiplosis oryzae, *W.*).—The pest has been recorded in the Northern Circars, Tanjore, Ramanathapuram and West Coast from the year 1914. The adult is a small mosquito like fly, the maggots of which burrow into the shoots and cause the characteristic silver shoots. Pale white or greenish blue, hollow outgrowths are developed as a result of the irritation caused by the maggots living inside, preventing the formation of the earheads. The loss caused is often serious. The fly is found to breed on a number of wild grasses also.

The fly deposits her eggs on the tender shoots which later hatch out into footless maggots and burrow into the shoots. Pupation takes place inside the hollow outgrowth and the adults emerge in due course. No tangible methods of control have been devised as yet, but a continuous setting of light traps in the infested areas attracts thousands of the flies and the trends of the infestation in such plots have been on the decrease.

The only natural enemy recorded is a wasp, *Polygnotus* sp. belonging to Platygasteroidea.

Field rats.—The cumulative effect of the damage caused by these non-hexapod pests to food crops like cereals, fruits and vegetables, is perhaps more heavy than that wrought by all the species of insects concerned put together. These rodents are under intensive study at the Agricultural Research Station, Aduthurai. Of the different categories occurring in the locality the mole rat—*Gunomys kok G.* the Gerbil rat—*Tatera cuvieri W.*—and the grass rat—*Millardia meltada, G.* appear to be the commonest and the following is a short account of the work done on the habits and control of these pests:—

(*a*) *The mole rat* (Gunomys kok, *G.*).—This is perhaps the most destructive species occurring in almost all the parts of this State. The adults can be recognized by their compact build, greyish brown colour and a short tail devoid of hairs. They are ferocious in temperament and show a positive disinclination to come out of their burrows even when disturbed. These rodents invariably live singly in tortuous burrows excavated generally on the field

bunds and occasionally in the field itself. The tunnels may extend to a length of 30 or 40 feet and to a depth of 4 to 5 feet with frequent blockings of earth. Each burrow may have four or five openings. The breeding is regulated according to the availability of the food material and litters are common from November up to February-March. These rats cause enormous havoc to rice in all its stages. Young seedlings in the nurseries are cut and the pieces stored in the burrows either for consumption or to serve as bedding. The damage is more serious when the crop is in shot-blade. The rodents appear to have a partiality for the sweet juice which exudes from the cut ends of the plants at this stage. The havoc perhaps reaches the peak when the crop is in ripe ears. Numbers of the earheads are cut and hoarded in the burrows and a quantity of even five pounds of grains has been recovered in individual cases. On a rough estimate, the damage caused by this rodent alone may come to 10 per cent.

Control.—Poison baiting with Strychnine, Paster of paris, Barium carbonate, etc., was tried with indifferent results. Fumigation with carbon-di-sulphide, sulphur fumes and later with calcium cyanide was the next stage in the control method. Though the inherent lethal effects of these fumigants have been established beyond doubt, their practical application in the case of these rodents has not met with a high degree of success for reasons mentioned below.

Under field conditions about 25 per cent of the burrows are invariably untenanted and as such the quantity of fumigants pumped into these burrows goes as waste. Even in the case of the tenanted burrows, the poisonous fumes are not always able to permeate into the innermost labyrinths of the tunnels, on account of the frequent blockings and definite success was recorded only in about 25 per cent of the burrows. On account of these inherent defects, the cost of destruction of these troublesome animals exceeded the economic limit of the average ryot. Local methods of digging out the burrows and killing the rats by professionals at a contract rate of about one anna per rat was cheaper and more efficient. The use of the 'bow trap', a very simple but ingenious invention of the Tanjore ryot proved to be equally effective, the cost being more or less the same. 'Antu' the much advertised rodenticide, was not at all useful in this case.

Zinc phosphide, another rat poison, was later given a fair trial. Though the efficacy of this chemical as a rodenticide, has been established beyond doubt, it was found that the mole rat—*Gunomus kok, G.*—the most destructive species—is somewhat shy of the baits. Critical studies on the comparative merits of the mechanical and chemical methods of control have shown that the number of the rodents exterminated by the former method exceeds that effected by the poison baiting by about seven times.

(*b*) The next species in importance is the Gerbil or the antelope rat—*Tatera cuvieri, W.* This species is distinguished from the others by its handsome buff colour, prominent bigger eyes and ears, long legs and a longer tail with a tuft of hairs at the end. They are very agile in habits and are capable of running fast and jumping up to a height of 2 or 3 feet. They live in shallow burrows, rarely exceeding 1 or 2 feet in depth having two or three openings. Unlike the mole rat, they are gregarious in habits and up to 12 specimens have been met with in a single burrow. This species also takes its own toll of cereals, but the control in this case is easier as these rats invariably run out of the burrows when disturbed. The better palatability of this species often serves as an incentive for their large-scale catching and extinction by the professionals. Zinc phosphide baiting also may be tried.

(*c*) *The grass rat* (Millardia meltada, *G.*).—This species occurs in fairly large numbers in the Tanjore Delta and is reported to cause a certain amount of loss to the rice seed beds. This rat may be distinguished from the other two by its smaller size, brownish grey colour and a white abdomen. The burrows are shallow with two or three openings. One of them is closed with a padding of grass over which a layer of earth is spread and packed and hence the name ' grass rat '. Another interesting feature is that these rats come out in their hundreds for feeding during nights. They get dazed by the light from an ordinary hurricane lantern or electric torch, when they can be easily chased and beaten to death. One interesting point worth mentioning here is that this species shows a remarkable preference to zinc phosphide baits.

2. Sorghum.

The Sorghum Earhead bug (Calocoris angustatus *L.*).—This Capsid is one of the earliest recorded pests of Sorghum in South India. It has a distribution extending almost all over the dry zones of India, but it occurs on a serious form only in this State, the areas most affected being the Ceded Districts, Guntur, Coimbatore and parts of Mysore. Stray adults appear along with the emergence of the flowerheads and multiply into serious proportions within a fortnight. They cause an enormous drain of the cell-sap by sheer weight of their numbers and the badly infested earheads turn black in colour and bear very few grains. The pest is, however, capable of little or no damage after the grains have hardened. The following details on the habits are worth mentioning here. At Coimbatore, two crops are raised. The first one is the irrigated Chitrai-cholam sown by March and the second is the dry Periamanjal crop sown by July-August. The irrigated crop is invariably more subject to the infestation. An interesting fact in this case is that it entirely escapes the damage if sown before

the 15th of March. The cause for this phenomenon is easily explained. The peak of incidence is by about the middle of May, when the grains have just set and begun to develop and this is incidentally the most vulnerable stage. The flowerheads of the earlier sown crops set and harden by this time and as such, damage if any, by the major wave is warded off. Conditions are different at Guntur since the local practice is to grow a series of three successive crops during a year and as such the pest is likely to pass from crop to crop with unmitigated virulence. Fortunately, the incidence of the pest appears to be controlled by certain seasonal factors also and as such its severity is not an annual feature. (Plate 119.)

Eggs are laid between the glumes and the nymphs hatch in five to seven days. They feed on the plant sap and reach the adult stage in the course of 10 to 15 days after undergoing five moults. It is estimated that under favourable conditions two generations of the pest are possible in a season, since the flowering of the ordinary types of sorghum is somewhat erratic and spread over a period of a fortnight. The bugs also breed on Setaria, maize, bajra, etc., though in insignificant numbers. This pest is remarkably free from any natural enemy except for a bacterial disease similar to Pebrine of silk worms, recorded some years back.

Control measures.—The futility of attempting to control the pest on a large scale appears to have been realized from the very inception of the investigations. The influence of a few changes in the cultural practices, such as adjusting the sowing period, frequent irrigations, manuring, etc., were studied with no conclusive results. By about 1936–37 dusting with sulphur indicated a reduction in the population of the bugs and increase in the yield. DDT and BHC are under trial as dusts on a field scale from 1946 onwards. The data indicate that both the chemicals have a high lethal effect on the bugs, the action of BHC being quicker and more thorough. The quantity of the insecticide required for an acre is about 20 to 25 lb. costing about Rs. 10. More recent experiments have indicated that the application of BHC dust 7 per cent at 15 lb. per acre gives satisfactory results. The trials with DDT and BHC were conducted under a special scheme financed by the Indian Council of Agricultural Research.

The Deccan grasshopper (Colemania sphenarioides, *B.*).—This is a wingless grasshopper which often occurs in hordes in parts of the Ceded Districts. It is indigenous to the Bombay State and must have spread only recently to parts of Madras State and also the adjoining tracts of Mysore, Hyderabad, etc. The hoppers appeared in a pest form during 1908 in the Ceded Districts and continued in all their virulence for about nine years till 1917. It receded to the background during the next eight years and flared up again during 1925, the second cycle extending up to 1931. The pest was again reported to be severe at Uravakonda during 1947

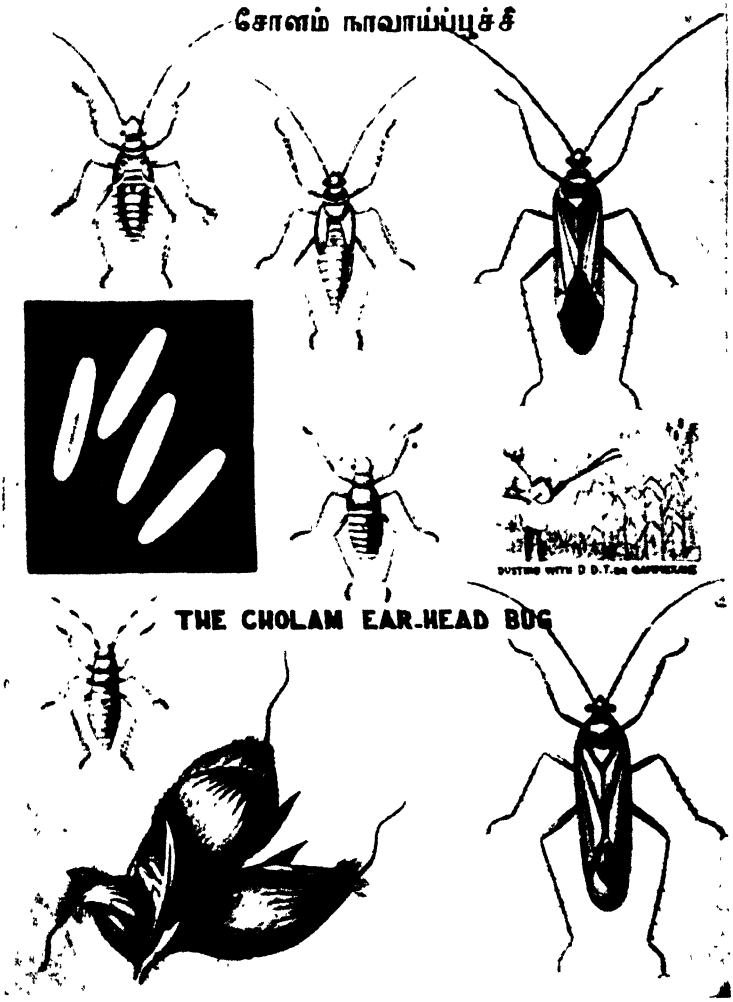


Plate 119.- *The cholam earhead bug*—Calocoris angustatus *L* P. 933

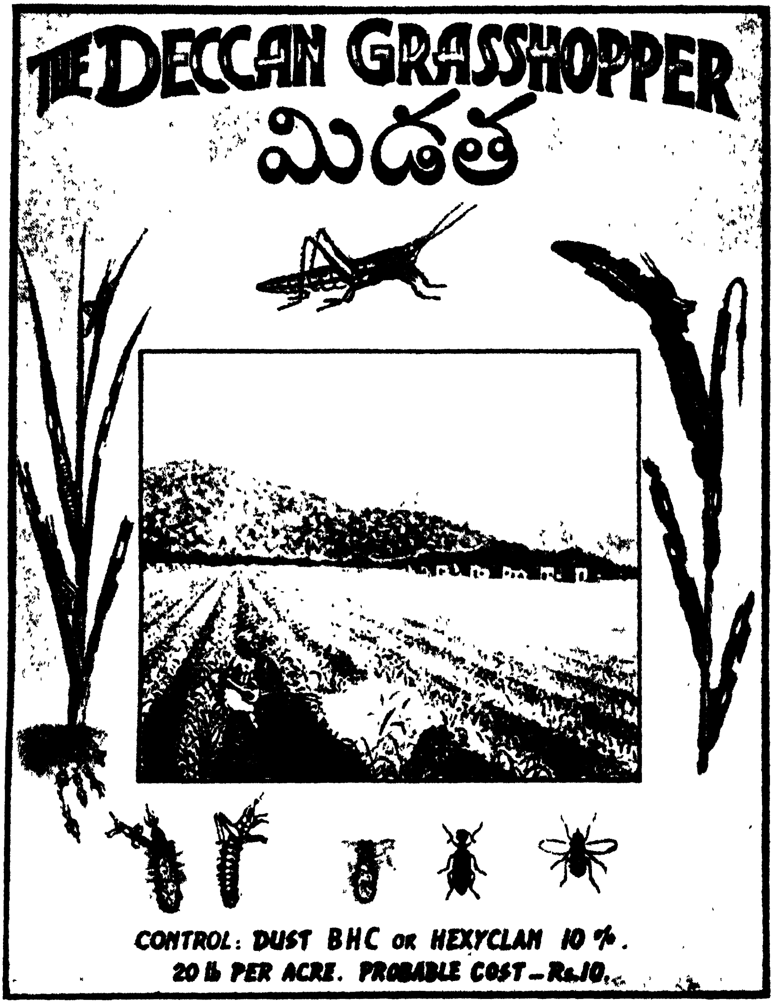


Plate 120.—*The Deccan grasshopper*—Colemania sphenarioides, *B.* P. 934

and reached more alarming proportions during 1948–49. There is thus some evidence to indicate a periodical cycle in the incidence of these grasshoppers. Dry crops like Sorghum, Setaria, etc., are subject to the attack of the pest from their very early stages, but the damage is felt most on Setaria from September-November, when the hoppers grow and concentrate on the earheads. The loss caused varies from 25 per cent up to a complete ruin. Eggs are laid in batches, two to three inches below the soil-level by about October-November. The nymphs hatch out during the succeeding July and begin to feed on the crops. The subsequent course of damage as well as the life cycle are more or less similar to those of the rice grasshoppers. In addition to causing appreciable damage to dry crops like Setaria, Sorghum, cotton, etc., this hopper takes to some pulses and also grasses growing wild in the waste land. (Plate 120.)

Natural enemies.—The maggots of a Bombylid fly, *Systœchus* sp. and the grubs of the blister beetle—*Zonabris* sp. prey on the underground egg-masses.

Control.—Various methods of control have been tried in different parts of the country. Huge drag-nets were passed over the infested crops but this method was neither efficient nor practicable. Ploughing up of the fields and hoeing with the Guntaka with a view to expose the egg-masses were given a fair trial during 1930, but the results were far from satisfactory. A hopper dozer was designed by 1931. The inner sides were painted with a resinous adhesive (castor oil and rosin) and the contraption itself was moved into fields when the hoppers were expected to jump about and get themselves stuck to the sticky mixture. A fairly good number of the nymphs appear to have been caught into the dozer, but the method by itself appears to have created very little impression on the local ryots. Further trials were taken up at Uravakonda with BHC D.025 during 1948, but the chemical had scarcely any effect on the pest which was mostly in the adult stage during the period of the experiments. The trials were, therefore, repeated during 1948–49 with DDT 3 per cent, BHC 5, 7 and 10 per cent and Hexyclan 10 per cent (another BHC product). The latter combination at 7 and 10 per cent had a specific action. The hoppers, both adults and young, were found to exhibit signs of discomfort in one or two hours, the actual death taking place some time later. The cost of the treatment works to Rs. 10 to Rs. 12 per acre and the method has passed the experimental stage.

The millet grasshopper (Hieroglyphus nigrorepletus, Bol.—This is another member of the category of grasshoppers, which often takes a major role on dry crops. It more or less resembles the rice grasshopper in appearance and has probably similar breeding habits. The damage by this species is not an annual feature but it assumed a serious form at Cuddapah during 1949,

threatening to devastate about 2,000 acres of ragi, Setaria, etc. BHC D.025 was also found efficient against the growing nymphs though adults require higher doses of BHC.

Other minor species consist of the lesser grasshoppers *Chrotogonus saussurii*, B. and *Aeolopus* sp. which are also controlled easily with BHC preferably seven per cent.

The Sorghum fly (Atherigona indica, *M.*).—This is a bad pest of the young crop in the Ceded Districts especially during the Hingari season. The insect is a small dark fly, the maggots of which bore into the stem, and kill the central shoot causing the characteristic "dead-heart". The crop is susceptible to the pest only till it is five weeks old. Eggs are laid by the female mostly on the under surface of the leaves. The maggots on hatching bore their way into the central shoot and cause its withering. The full-grown maggot is yellow in colour about 10–12 mm. in length and generally pupates inside the plant. The entire life-history takes about 15 to 20 days. Types like M. 47-3, T-1, PB2R are reported to be resistant while AS. 2095 is more susceptible. The pest is under investigation at the Agricultural Research Station, Siruguppa. Earlier methods of control consisted of the adoption of a higher seed rate and thinning out the infested plants subsequently. As this was found far from perfect, experiments on the relative efficacy of flooding with and without Fish Oil Rosin Soap, manuring, drilling BHC and DDT along with the seeds, periodical application of BHC and DDT sprays, etc., were in progress and of these, the BHC spray has given some promise of control.

The Sorghum stem borer (Chilo zonellus, *S.*)—This is one of the serious pests of the Sorghum crop during the earlier stages. The larvae bore into the stem and cause the central shoot to wither. The insect is distributed throughout the Sorghum tracts of South India.

The straw-coloured female moth lays batches of scale-like flattish, oval, overlapping, eggs usually on the undersurface of the leaves. The caterpillars, on hatching out, bite their way into the stem and feed on the tissues eventually killing the central shoot. Pupation takes place inside the tunnel itself, the whole life cycle from egg to adult occupying six to seven weeks.

Alternative host plants.—Besides Sorghum, the insect is found to breed on Ragi and maize.

Natural enemies.—In addition to the egg parasite—*Trichogramma* sp.—the following Hymenopterans have been found to parasitise the larvae : *Xanthopimpla, pedator*, F. *Xanthopimpla nursei*. Cam., *Iphiaular sp., I. spilocephalus*, Cam. *Marionotus* sp., *Apanteles flavipes*, Cam., *Apanteles* sp., *Glyptomorpha (Bracon) deesae* Cam.. and *Microbracon chilocida, Ram.* and *M. chilonis, V.* The pupae are attacked by the Eulophid *Tetrastichus ayyari*, Roh.

Plate 121.—*The cholam fly*—Atherigona indica, *M*.

P. 937

Control.—As in the case of all borers, the external application of insecticides will be of no avail. The only palliative would be to increase the seed rate, and pull out the dead-hearts subsequently.

Biological control with the help of the Chalcid egg parasite *Trichogramma* sp. is being attempted on a field scale and it is too early to pronounce any definite results.

The Sorghum mite (Paratetranychus indicus. *H.*).—This minute greyish green Arachnid attacks the leaves and causes bright red blotches on the lower surface of the leaves. The discolouration extends in area along with the increase in the virulence and hundreds of these mites can be found under a delicate webbing. They scrape the leaf surface and very often the entire leaf surface of the plant will be affected. Eggs which are white and spherical hatch in three or four days. The larvae have three pairs of legs while the adults are provided with four pairs. The whole life cycle lasts from nine to twelve days.

Alternative hosts.—The same species of mites has been noted on the common grasses,—*Panicum javanicum*—*P. distachyum* and on sugarcane.

Natural enemies.—The important natural enemies of mites studies at Coimbatore are *Scymnus gracillis*, M. (Coccinellidae), *Scolothrips sexmaculatus*, P. (Thripidae) and (*Oligota flaviceps*) (Staphylinidae) but none of them occur in sufficient numbers to effectively check the pest.

Control.—Dusting with flowers of sulphur is the acknowledged remedy for this pest.

3. Ragi.

This millet is subject to damage by two borers, viz., the pink borer—*Sesamia inferens*, W. and the white borer—*Saluria inficita*, W. The habits as well as the nature and extent of damage are similar in both the cases, the larvae boring into the stem and eventually killing the central shoot. The pink borer occurs also on wheat, maize, sugarcane and sometimes on rice as well. The larvae are parasitised by a few Hymenopterous insects. The white borer has been recorded also on Setaria and rice.

Control measures.—Very little is possible by way of control of these borers. Pulling out the dead-hearts and adopting the ordinary methods of plant sanitation may help in reducing incidence.

The Ragi root Aphis (Tetraneura hirsuta, *B.*).—These are minute pale white insects found in groups on the roots of plants. They suck up the nutrition with the result that the infested plants are dwarfed in size and slowly wither away. The infestation by these aphids is invariably indicated by the presence of large numbers of ants round about the roots of the plants. The pest is, of late, assuming serious proportions round about Coimbatore.

Control measures.—Mixing small quantities of crude oil emulsion, Tar water or Fish Oil soap with irrigation water is advocated, but the results are far from satisfactory. Definite control measures have yet to be evolved for this pest.

4. Pulses.

Redgram.—Redgram is the most important crop under this category and it has to contend with a number of insect enemies which attack it in its different stages.

The gram caterpillar (Heliothis obsoleta, *Fb.*).—This is a serious pest of cotton in America, but is rarely seen on this crop in South India. Shiny greenish yellow eggs with a sculptured surface are laid on the tender parts of the plant. The caterpillars on hatching feed on the foliage and bite through the pods and devour the seeds from outside. The full grown larva is about an inch and half in length. The body colouration is generally green with a whitish streak and a number of setae and tubercles. Pupation takes place inside the soil. The pest is polyphagous in habits and attacks a variety of crops like Bengalgram, cotton, groundnut, tomato, tobacco, opium, ganja, etc. The caterpillars are sometimes kept in check in nature by a few Dipterous and Hymenopterous parasites. A pentatomid bug, *Andrallus spinidens*, F. was found sucking the larvae on linseed at Coimbatore.

Control measures.—Arsenical sprays may be useful when the caterpillars feed externally but have little or no effect after they begin to bore into the pods. Hand picking has been suggested in severe cases. Cursory trials with DDT and BHC have indicated the possibilities of control.

The redgram plume moth (Exelastes atmososa, *W.*).—This is a specific pest of redgram. The caterpillars bite into the pods and feed on the seeds from outside, thrusting in only their head. They pupate on the pod surface and the pupae are fringed with a number of short hairs and spines. The adult is a slender moth with the wings arranged in plumes.

Control measures.—No feasible methods are available at present except those recommended for the previous pest.

Besides these, the crop is regularly infested by a variety of insect pests of minor importance.

Bengalgram.—The most serious pest of this crop is *Heliothis obsoleta*, H. already mentioned under redgram.

The other pulse crops, viz., green and blackgram, horsegram, and cowpea have their own specific enemies of which aphids play a major part. These can be easily controlled by tobacco spray. Other pests consist of the sweet potato sphinx—*Herse convolvuli*, L. one or two species of *Alcides* sp. and *Agromyzid* flies. As these pests are only of minor importance, no serious attempts have been so far made towards their control.

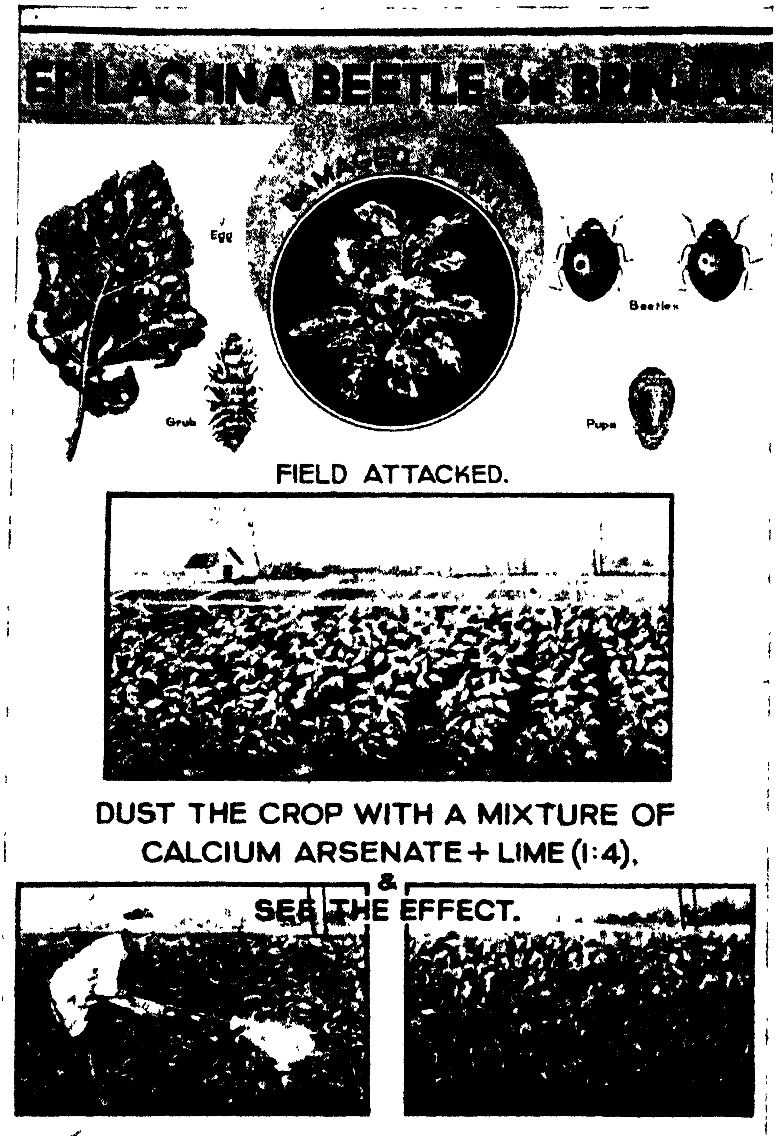


Plate 122.—*The brinjal beetle*—Epilachna *spp.* P. 942

5. VEGETABLES.

Brinjal.—Of the numerous insect pests, which attack the crop, the brinjal beetle (*Epilachna* sp.), the fruit borer (*Leucinodes orbonalis*, G.) and the budworm (*Phthorimoea blapsigona*, M.) constitute the major forms. Lace wing bug (*Urentius echinus*, D). is another pest of brinjal which sometimes becomes serious but it can be controlled by BHC or DDT.

The brinjal Epilachna (Epilachna 12 punctata, *M.* and E. 28 punctata, *F.*).—This is an important leaf-eating pest. The adults are hemi-sperical in shape and pale red in colour with a number of black spots. The grubs are fleshy, spiny and yellow in colour. Both the adults and grubs scrape and feed on the green matter of the leaves causing an appreciable damage. The beetles are equally severe on bitter gourd, tomatoes, potatoes, etc. (Plate 122.) Two species of Eulophid parasites—*Aprostocetus* sp.—attack the grubs and keep the pest under control during certain seasons. A reduvid predator *Rhinocoris fuscipes*—may also be mentioned in this connection as a netural enemy.

Control.—Calcium arsenate either as dust (1 :6) or spray (1 to 2 oz. in one gallon of water) has been found very effective. Recent investigations with DDT and BHC conducted under a special scheme financed by the Indian Council of Agricultural Research showed that though DDT was effective, its application was invariably followed by a heavy incidence of the mite—*Tetranychus telarius*, L—and as such the time honoured treatment is preferable.

Of the other two pests, the brinjal fruit borer (*Leucinodes orbonalis*, G.) and the bud worm (*Phthorimoea blapsigona*, M.) the former is a medium sized moth with whitish wings. The cater pillars are short, stout and pinkish in colour. They bore into the shoots and fruits causing considerable havoc. The latter is a tiny brown moth and the caterpillars bore into the tender buds. The damaged buds invariably drop off.

Calcium arsenate spray, tobacco decoction, Bordeaux mixture, 2 per cent DDT, 2 per cent BHC and *Thevetia* extract were tried against these two pests from 1941 onwards. Calcium arsenate spray was found significantly superior to all the others.

The Bhendai (cotton) jassid.—(Empoasca devastens, *D.*).—The same species which attacks cotton infests this crop also. The damage is equally severe. The leaves get yellow and crinkled and the plants are stunted in growth and the yield is very poor.

Control.—The approved method of control like spraying tobacco, lime sulphur, etc., not being effective, a fair trial was given to the new chemicals BHC, DDT and HETP. It was definitely established that BHC had little or no effect on these jassids while DDT, either as dust 5 per cent or spray 0·1 per cent had spectrcular effects and the yield in some cases apprecited by 700 per

cent over the control. The cost of treatment per acre works out to about Rs. 6. It has also been found that the use of DDT on this crop brings in its wake a heavy attack of mites,—*Tetranychus* sp.—which may be controlled by sulphur. HETP spray also exerts a very high lethal action but the results have to be confirmed.

The chillies thrips (Scirtothrips dorsalis, *H.*).—One of the common ailments of the chillies crop is what is popularly known as the leaf curl disease. The causative agent is a thrip—*Scirtothrips dorsalis*, H. This minute insect is yellow in colour, with fringed wings and attacks the crop in all its stages sucking up the nutrition from the leaves, buds and flowers. Eggs are inserted in the leaf tissue and the nymphs hatch out in four or five days. The newly hatched nymphs are pale white in colour and attain the adult stage within 10 to 15 days after undergoing two moults. These thrips have been recorded to breed on castor and a variety of other plants in addition to chillies. The pest was first reported to be serious at Guntur in 1926 and observations on its life-history, habits and control were started from 1927 onwards. Tobacco dust or spray was found to give appreciable relief, but the treatment had to be repeated according to the severity of the incidence. The cost of dusting worked out to Rs. 5 while that of spraying was Rs. 10 per acre.

Subsequent trials with a number of insecticidal sprays like Lobelia decoction, Acorus decoction, Fish Oil rosin soap, Pyrethrum, etc., show that none of these were superior to tobacco. Further investigations with BHC and DDT as dusts at various concentrations under a special scheme of the Indian Council of Agricultural Research proved that BHC, 3 to 5 per cent is an effective remedy.

The garlic and onion thrips (Heliothrips indicus, *B* and Thrips tabaci, *L.*).—These two species of thrips constitute the major pests of garlic and onions. Of the two, *Thrips tabaci*, L. is more serious and the loss is particularly severe on garlic as the produce is more valuable. Investigations on the control of these insects with special attention to *Thrips tabaci*, L. on garlic were initiated at Siruguppa as early as 1929 and some interesting information on the life-history and habits, control, etc., was gathered. (Plate 123.)

Stray adults are found on the plants by November but they multiply to such a degree within a short time that the plants teem with the population by December, the mild, bright sunny weather being favourable for their prolific multiplication. Both the adults and the young lacerate the tender portions and suck up the plant nutrition. The females insert their eggs singly inside the plant tissues, generally more in the basal leaf stalks, out of which the nymphs hatch out in due course. They feed and develop on the plant and ultimately pupate in the soil. The population lurks inside the recess of the leaf stalks but may often be seen outside as well.

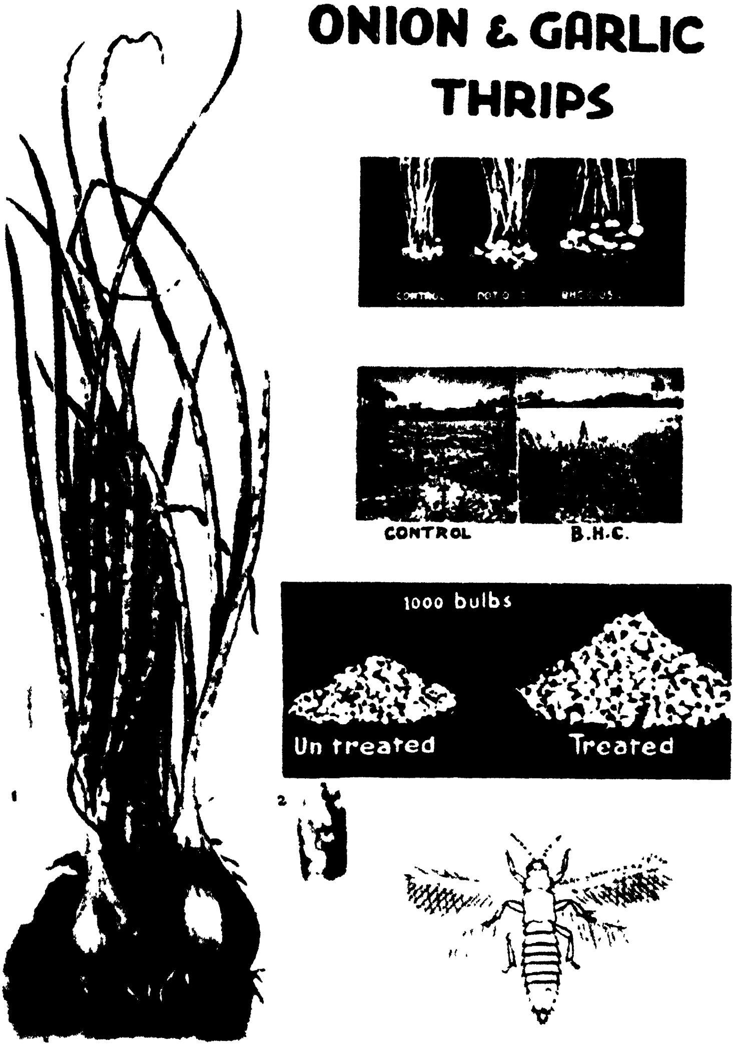


Plate 123.—*The garlic and onion thrips*—Thrips. tabac, *L.*). P. 945

Alternative host plants.—Heliothrips indicus, B. has been collected from a host of other plants, viz., Indigo, berseem, onions, brinjal, Cannabis sativa, sunnhemp, cabbage and cauliflower. *Thrips tabaci*, L. occurs freely on flowers and shoots of cotton, cabbage, onions, tea, etc.

Control measures.—Tobacco extract (1 lb. in 6 gallons) with a strong dose of one pound of soap, lime sulphur 1 in 15 to 1 in 20 with soapnut lather were given a fair trial. The treatments, instead of conferring any benefit were found to be decidedly harmful to the foliage. The higher concentration of soap definitely retarded the plant growth, while the lime sulphur resulted in scorching foliage. Mechanical methods like sweeping the insects with a cardboard smeared with some adhesive were equally fruitless. Better methods of cultivation with a heavier dose of manure, more copious and frequent irrigations with an occasional use of tobacco dust were recommended as tentative measures. Recent trials with different combinations of DDT and BHC have given spectacular results. BHC spray even at 0·05 per cent caused a very high mortality on the population. Eight pounds of the chemical (costing about Rs. 13) in 100 gallons of water are required to treat an acre and a second treatment may be necessary in cases of severe infestation. The sprayed plots gave an additional yield of about 2,500 lb. per acre, over the control, and the approximate money value was Rs. 1,000. The increased yield is brought about by the more vigorous growth of the sprayed crops and the consequent better development of the bulbs. The method has passed the experimental stage and the ryots are fast taking it up of their own accord especially round about Palladam in Coimbatore district.

Pests of Cruciferous crops.—Among the serious pests which infest these exotic vegetables, two species of cut worms, Euxoa sp. and Agrotis sp. are the most important. The caterpillars are smooth, cylindrical and somewhat dark in colour. They generally hide under the clods, crevices, hedges or any thick vegetation nearby and move in groups during nights, causing wholesale havoc by cutting the young plants at ground level. Recently, the tobacco caterpillar—*Prodenia litura*, F.—was also noted to cause a similar damage to young snake gourd plants at Coimbatore. Dusting with BHC D.025 was found to give spectacular results in the case of the cutworms on cruciferous crops. As regards the snake gourd plants, the chemical is likely to injure the tender plants if applied direct on them. It was, therefore, strewn round the beds. The caterpillars while crawling towards their food plants came in contact with the insecticide and died in numbers.

The cabbage borer **(Hellula undalis,** ***Fb.*****).—The adult is a pale yellowish brown moth with wavy grey markings on the wings. In its early stages, the caterpillar mines the foliage, feeds on the shoots and later burrows into the central stem. It pupates in the burrow after attaining a length of two-third of an inch. It is**

rather difficult to control the insect except by preventive measures such as destroying or plucking off early attacked plants.

The Diamond back moth (Plutella maculipennis, *C.*).—The eggs are laid singly on the tender parts and the caterpillars on hatching feed on the foliage and grow to about one-third of an inch in length. Pupation takes place inside a transparent silken cocoon. The moth is small in size and has pale white marks on its wings.

Brachymeria excarinata, G. and *Tetrastychus sokolowskii*, K. have been recorded as pupal and larval parasites respectively.

The Mustard sawfly (Athalia proxima, *K.*).—This is a unique example of a Hymenopterous insect assuming the role of a crop pest. The larva is a leaf-eater and does substantial damage to radish, mustard and allied plants grown on the hills. Eggs are laid inside the plant-tissue and the larvae feed on the foliage, grow to a length of about an inch and pupate inside the soil in an earthern cocoon. The grubs are characterised by the possession of eight pairs of prolegs. The Pentatomid bug (*Canthecona furcellata*, W.) is predaceous on these grubs. Handpicking of the grubs and a judicious application of stomach poisons in cases of serious outbreaks may give considerable relief. Plant bugs like *Nezara viridula*, L., *Bagrada picta*, F., *Aphids*, etc., are some of the minor pests.

Pests of Cucurbitaceous plants.—The major pests of these vegetables comprise of leaf caterpullars, pumpkin beeler, fruit flies, plant bugs and aphids.

The pumpkin caterpillar (Margaronia indica, *S.*).—This caterpillar is bright green in colour and is characterised by the presence of longitudinal white streaks along the mid-dorsal line. It feeds on the foliage and pupates inside a leaf fold in a flimsy silken cocoon. The moth can be recognised by its whitish wings with dark broad marginal bands and the tuft of orange coloured hairs at the anal end.

The snake gourd semilooper (Plusia peponis, *F.*).—This is a semilooper usually infesting the snake gourd. The female lays her greenish white spherical sculptured eggs on the tender leaves generally on the lower surface. The caterpillars have the habit of cutting and rolling out portions of the leaf and feeding from inside. The body is greenish with white stripes and is provided with blackish warts, bearing tufts of short hairs with the anal segment slightly humped. It attains full growth of about 1½ inches and pupates inside the fold in a cocoon padded with plenty of white silk.

The natural enemies recorded are *Apanteles plusiae*, Vier, *Mesochorus plusiephilus* Vier. on *Plusia peponis* F. and *Paracopidosomopsis javae*, G. on *Plusia signata*, F. and *Ceraphron athanasii*, G. on *Plusia agramma*. Handpicking as well as arsenical sprays are advocated.

Pumpkin beetles (Aulacophora foveicollis, *F.*), (A. atripennis, *F.*) and (A. stevensi, *B.*).—These bright coloured beetles feed on the leaves of cucurbitaceous plants. The grubs feed on the underground roots and pupate in the soil. The bettles can be collected and destroyed with nets. Stomach poisons also can be used in severe cases.

Fruit flies (Dacus and Chaetodacus *sp.*).—Shining white cigar shaped eggs are thrust into the tissues of the ripening fruits. They hatch out into footless maggots which bore through and devour the fruit pulp. These later drop out, pupate under the soil and emerge as flies in about a week or ten days. The adults are characterised by triangular shaped abdomen and spotted wings.

Only preventive measures are possible for controlling this pest. The damaged fruits should be destroyed. Attempts to trap the flies with poisoned baits have not met with any remarkable degree of success so far. In addition to these specific pests, the brinjal *Epilachna* also attacks some of the plants belonging to this category.

House bean (Dolichos lablab).—The lablab bug—*Coptosoma cribraria*, F.—can often be seen resting on the vines in its hundreds generally in the later stages of the crop. They suck the plant sap as a result of which the creepers wilt off. This bug is found to infest redgram, indigo, agathi, pongamia, etc. Dusting of the affected plants with BHC D·025 gives definite relief.

The podborer caterpillar (Adisura atkinsoni, *M.*).—Isolated spherical eggs are laid on the tender pods. The caterpillars on hatching bore into the pods. The full-grown caterpillar attains a length of $1\frac{1}{4}$ inches and pupates under the soil. The adult is a pale yellow brown moth. The larvæ are attacked by *Microbracon* sp. Control measures similar to those of the gram caterpillar can be adopted.

The plant lice (Aphis medicagenis, *K.*).—The insect constitutes by far the most common and serious pest of these vines in South India. Colonies of these dark coloured insects appear in the tender vines and are capable of completely ruining the crop unless checked in time. As in the case of the other aphids, these also are kept in check by lady bird beetles *Chilomenes sexmaculata*, F. and their larvæ, along with syrphid and lacewing fly maggots.

Control.—Spraying tobacco decoction with a little soap or Fish Oil Rosin soap in the strength of one in six gallons of water is the approved remedy. As the former commodity is of late becoming too costly and difficult to procure, attempts were made to find out a substitute. BHC dust and spray, HETP spray, etc., seem to serve the purpose quite well.

Sweet potato.—This tuber has, of late, assumed some importance as a subsidiary food to augment the food supply and has a few insect enemies to contend with.

The sweet potato weevil (Cylas formicarius, *Fb.*) is the major pest both in the field as well as in the godown. The adult is a dark blue ant-like weevil with reddish thorax about 1/3 inch in length. It is distributed all over the tropics. The major damage is caused by the grubs which bore tortuous tunnels into the vines and tubers. The adults also nibble at the tender vines and tubers. The parent lays oval whitish eggs inside small cavities made on the host surface. The pale white grubs, on hatching, bore into the plant tissue and scores of them are ordinarily found inside each tuber. The larvae pupate in the host material in about a fortnight and the adults emerge in another week. No alternative host plants have been recorded in South India.

Control.—No effective method has yet been evolved. The planting of the pest-free vines and storage of the tubers under sand will go a great way to minimise the damage. Fumigation with methyl bromide at the rate of one pound per 1,000 c. ft. for four hours is said to destroy all the stages of the weevil.

Other pests of this tuber crop are tortoise beetles like *Aspidomorpha miliaris*, F., *Metriona circumdata*, H. and *Chiridia sexnotata*, B., and a small hispid beetle *Oncocephala tuberculata*, O., also. The Lepidopterous pests consist of the sweet potato sphinx—*Herse convolvuli*, L. and a few others of minor importance.

The potato tuber moth (Gnorimoschema operculella, Z).—This is occasionally a serious pest, the special feature being that it infests the tubers both in the field and the godown. The damage is probably heavier in the store-room since hundreds of the small brownish moths can be seen flying about inside these places. The pest is chiefly found on the Nilgiris, Shevaroys and Mysore plateau. In the godown, the parent lays her eggs near the eyes of the potatoes and the pale whitish brown caterpillars begin to burrow into the tuber. Pupation takes place inside a coarse silken cocoon either on the tuber itself or on the gunny bags.

Control.—A number of insecticidal dusts like Pyrethrum, Derris, tobacco, sulphur, DDT and BHC were tried in the godown with no conclusive results. Attempts at biological control with the egg parasite—*Trichogramma minutum*, R—and the larval one—*Microbracon gelechiae* Ash—were equally unsuccessful. By far the best method would be to maintain proper sanitary conditions in the godowns.

Recent trials with BHC and DDT sprays indicated the efficacy of the former towards the control of the borer in the field.

6. Fruits.

The mango hopper.—Three species of these jassids, viz., *Idiocerus niveosparsus*, L, *I. atkinsoni*, L, and *I. clypealis*, L. have been recorded to infest mangoes in this State from the year 1913 onwards. The adults are active wedge-shaped insects, breeding on the flower-heads and tender leaf-shoots. Eggs are thrust into the

SPRAYING FOR MANGO HOPPER

மாமரத்துத் தத்துப் (தேன்) பூச்சிக்கு மருந்தடித்தல்

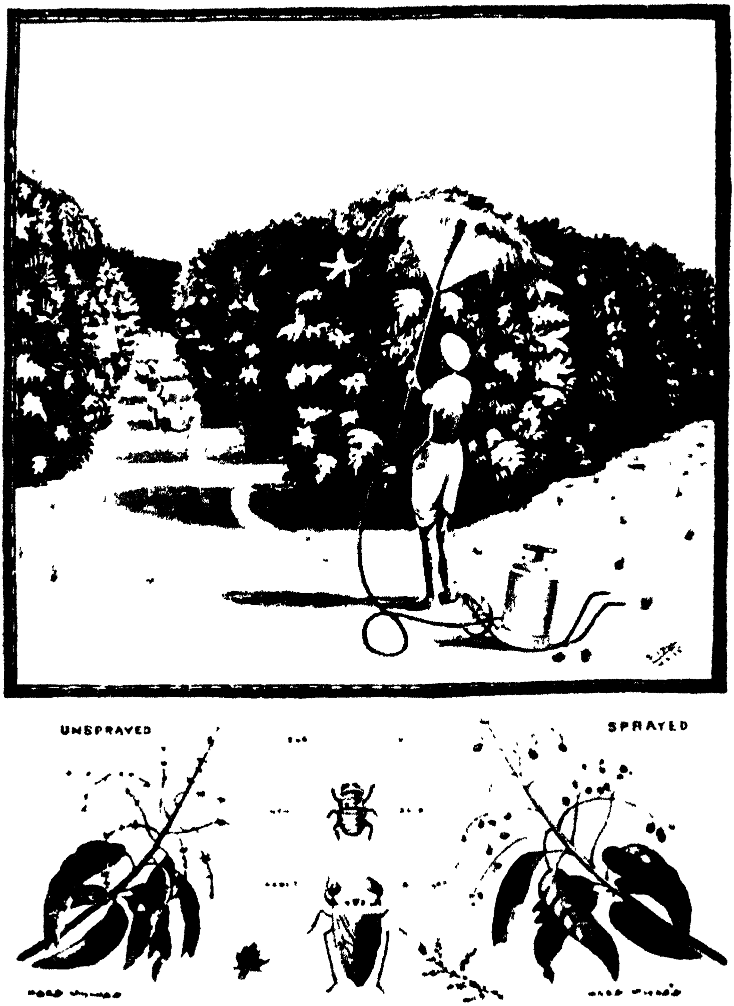


Plate 124.- *Spraying for mango hopper*—Idiocerus *sp.* P. 952

tender tissue of the flower stalks and growing shoots through minute slits made for the purpose. The nymphs hatch out within a week, feed on the sap from the succulent portions and reach the adult stage in about 10 to 12 days. The pest multiplies at an enormous rate during the flowering season and two to three generations are possible between January to March. The clicking noise made by the myriads of the hoppers by jumping from leaf to leaf can be heard even from a distance. The adults and young secrete large quantities of a sweet sticky fluid "honey dew" which collects on the leaves imparting a glistening appearance. The fungus "sooty mould" develops on the fluid matter, rendering the entire foliage black. The damage caused by the hoppers is more severe in years when the flowering is early, i.e., by December-January. *Pepunculers annuliferum* Brun, *Pyrilla oxenos compactus* Pierce, *Epipyrops fuliginosa* Tams, and a *Dryinid* wask have been recorded as parasites on these hoppers in Mysore State.

Control.—Fish oil rosin soap at the strength of 1 lb. in 10 gallons of water was advocated as a remedy against the nymphs only. Sulphur has given good results against the hopper as well as the fungus 'mildew'. DDT also promices to be a very effective control against the pest. (Plate 124.)

The mango stem-borer beetle (Batocera rubus, *L.*) comes next in importance. The adult is a big sized Cerambycid beetle, dull yellowish brown in colour with a few bright orange spots on the upper wings. It is further characterized by the possession of long legs and longer antennæ. The eggs are inserted singly under the loose bark or in wounded or diseased portions of the branch. The grubs on hatching begin to burrow into the stem. The larval period is fairly long and the full-grown grub is stout, yellowish white in colour and about four inches in length. The head is flattened and dark with the mandibles very strongly developed. The grub spends its entire life inside the stem, boring and feeding on the internal tissues. The infested branch eventually dies off. No prominent external symptoms of the damage are indicated except for the oozing out of the reddish sap along small bits of frass from the bore holes.

Control measures.—Infested branches may be sawn off and the cut surface painted with tar. The grubs may be hooked out with a barbed wire or destroyed *in situ* by syringing in a small quantity of kerosene, petrol, mixture of creosote and chloroform, etc. Chlorosol may also be tried.

The mango shoot webber (Orthaga exvinacea, *W.*).—The insect is found throughout the State and is serious at Coimbatore from February to October. The caterpillars have the habit of webbing together the leaves at the terminal ends, and preventing the proper development of the flower-heads. The female lays her yellowish green eggs singly near the ribs of the leaf. About 30 to 35 eggs are laid by an individual. The larvæ hatch in about four days and are pale green in colour. They feed gregariously on the chlorophyll during the earlier stages. The full-grown larva is about 3·5 cm.

in length and the pupal period lasts about 10 to 14 days. A Carabid beetle—*Parena laticicta B.*—and a Reduviid bug—*Occama sp.*—have been noted to feed on the caterpillars. The pest makes itself scarce in the presence of the red ant—*Oecophylla smaragdina*, Fb. A Braconid—*Hormius* sp. has been found to attack this insect occasionally.

Control.—The affected bunches can be collected with the caterpillars *in situ* and destroyed. Spraying the foliage with calcium arsenate is fairly effective. Recent trials with BHC sprays at 0·05 and 0·1 per cent have given very encouraging results.

The red tree ant (Oecophylla smaragdina, *F*).—These ants have a peculiar habit of webbing together the leaves in the form of a nest and establishing themselves in colonies on most fruit trees. Long trains of these troublesome insects can be seen moving about all over the trees and their chief food consists of the secretions from the scale insects, mealy bugs, etc., which commonly infest these trees. The ants, apart from rendering the approach to the trees difficult by their vicious stings, are also responsible for tending the colonies of the scale insects and mealy bugs and even for distributing them from tree to tree.

Control measures.—The success of control lies in the destruction of the nests. The usual practice is to burn them during nights when all the members are inside. Blowing in a few whiffs of calcium cyanide will also exterminate the colony. Recently spraying with BHC even at a low concentration of 0·025 per cent was found to have a very high specific lethal action, the residual effects being perceptible for nearly a week.

The castor slug (Parasa lepida, *G.*).—This is a polyphagous pest having a wide range of hosts of which fruit trees like the mango and pomegranate are but a few. The caterpillars, popularly known as slugs, are thick, flattish and green in colour with a few pale or bluish stripes. They are provided with a series of tufts of spines on the body which are highly irritant in action. The caterpillars often defoliate the trees. The adult is a green coloured moth with prominent dark patch at the base of each forewing. Batches of the scaly eggs are laid on the leaves and the caterpillars on hatching feed gregariously for a few days and disperse later. Pupation takes place inside hard shell-like greyish cocoons, which are also equally irritant. Hundreds of such cocoons can be seen in groups on the tree trunks. (Plate 125.)

Alternative host plants.—The insect is also serious on castor and of occasional importance on trees like coconut, palmyra palms, wood-apple, etc. Three hymenopterous parasites—*Clinocentrus* sp. —*Stomatocerus ayyari*, G. and *Eurytoma parasae* G. and an interesting predatory caterpillar—*Phycita denticinella* H. may be mentioned under this category.

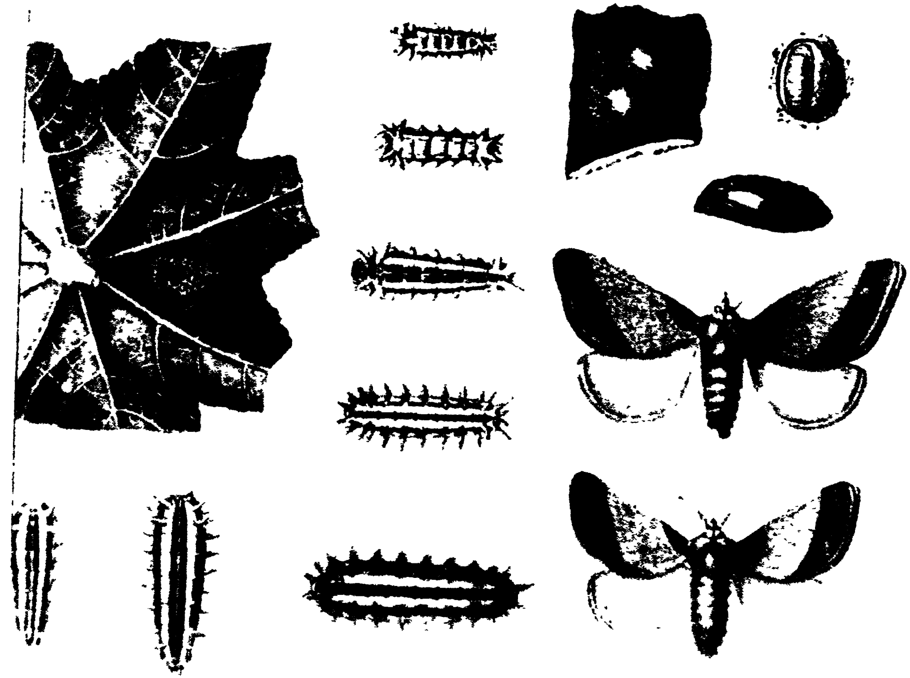


Plate 125. The castor slug. Parasa lepida, *G.*

P. 955

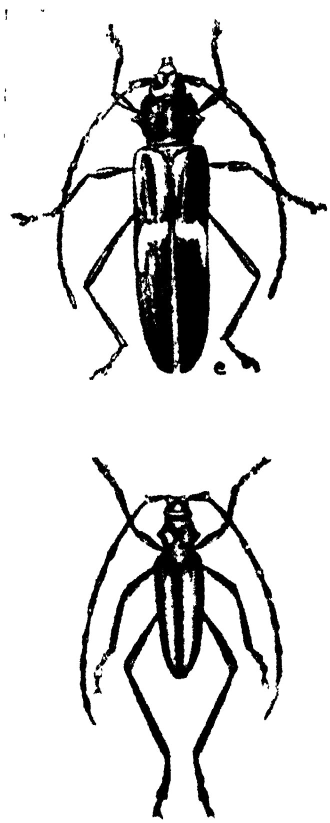


Plate 126.—*The orange borers.*—Chelidonium cinctum, *G.* Chloridolum alcmene, *T.* P 956

Control.—The control can be easily effected in the earlier stages by plucking the leaves with the young caterpillars when they are gregarious and destroying them. Dusting or spraying with arsenical poisons may be necessary if the caterpillars have distributed themselves. Dusting with BHC D·025 had spectacular effects. The cocoons also can be destroyed mechanically, taking care to see that the broken pieces do not come in contact with the operator.

The orange borer (Chelidonium cinctum, *G.*)—The extension of the cultivation of mandarin oranges on a large scale to the Wynaad tract, has, in its wake, created a few insect problems, of which the most important is that of the Cerambycid borer. Its depredations are already well known in parts of the Mysore State and Coorg. The pest was reported from Wynaad only during 1948, but from its widespread incidence as well as the virulence of infestation, it is obvious that the borer has been there for some time. The adults are fairly big-sized beetles, uniformly bluish green in colour. But a majority of the specimens of the same species occurring in Mysore and Coorg are reported to have two prominent yellowish patches on the elytra. The following is a short account of the life-history of the pest.

The adults emerge soon after some heavy showers during June-July and lay their eggs singly at the branch-axils at the terminal ends. The grubs hatch out in about 12 days and begin to bore inside the stem. They effect a spiral cut disconnecting the bark from the core and burrow upwards for a period of 2 to 6 weeks, feeding on the internal tissues. The infested shoots begin to fade as a result of the damage. The grubs later reverse the direction of their progress, enter the thicker branches below and eventually the main stem. They ramify and feed on the woody portion and their activity is evinced by the ejection of appreciable quantities of chewed fibrous material through the bore-holes. The larval period extends for about 10 months after which the grubs pupate and the pupal stage lasts for about 3 to 4 weeks. The beetles emerge after some sharp showers by about May, wait inside the tunnels till their body gets hardened and come out later after the receipt of the next heavy rains. There is a wide variation in the number of the borers found inside a tree. An instance of a single tree harbouring 26 of the newly emerged beetles was recently noted. The damage which such a large number of these borers can effect on a single tree during an entire season of about 10 months can be better imagined. Repeated infestations to such a severe degree year after year might gradually devitalize the tree and make it susceptible to other diseases which might ultimately cause its death. Extensive trials with DDT and BHC sprays were continued to study whether the chemicals exert any deterrent or lethal action. Though a few washes of the latter caused a certain amount of reduction in the infestation, the prohibitive cost as well as the practical difficulties encountered in conducting the spraying operations during the high monsoonish weather in the hilly tracts are not commensurate with the relief obtained. A very simple expedient by way of clipping

the wilted shoots with the grubs inside, within the critical period of six weeks (i.e.) before they enter the branches below, has been evolved and is being advocated in Mysore as an efficient measure. The same method was adopted at Wynaad with a remarkable degree of popularity. The quintessence of success lies in the fact that the pest is tackled in its most vulnerable stage before it causes any appreciable damage. The cost of operation has been computed to be Rs. 4 per acre.

While the above method is almost infallible against the young grubs, more recent experiments against the grown up larvæ in the main trunks, have shown that they can be effectively destroyed by injecting small quantities of petrol with a hypodermic syringe. The cost per tree works out to about As. 1½.

The fruit sucking moths (Ophideres *spp.*).—Fruit moths have been a serious problem since 1921. Investigations show that the adults of three different species, viz., *Ophideres fullonica*, L. *O. materna* L. and *Anua coronata* F. visit the orchards during nights and pierce the ripening fruits with their long, sharp proboscis and suck up the sweet juice. Such fruits very soon develop a rot right round the seat of puncture and drop off. The female lays her eggs on the host plant generally *Tinospora*, etc. The caterpillars hatch out in three days and feed on the tender leaves. The full-grown larva is about 2 inches in length, velvetty dark in colour with a few prominent white and red spots. They subsequently spin the leaves together and pupate inside. The larval and pupal stages extend to 19 and 9 days respectively. One or two unidentified species of wasps have been bred from the eggs. Two other species-*Euplectrus lencos Famus* Roh and *Tetrastichus ophiusae* (craw) parasitise the caterpillars. Besides these, the larvæ are preyed upon by birds, blood-suckers, etc. (Plate 127.)

Control.—The control methods suggested in earlier years were trapping the moths with poisoned molasses flavoured with fruit essences and destruction of the host plant—*Tinospora cordifolia*. Light traps were tried in 1935 but were of no avail. Crude oil emulsion was found to be a good deterrent, but its action lasted only for two or three days. Growing tomato as a trap crop met with only indifferent results. Though the cumulatrve effects of all these methods may be appreciable, they are still capable of considerable improvement. DDT sprays are showing some promise.

The citrus butterfly (Papilio demoleus, *L*).—The adult is a beautiful black and yellow swallow tailed butterfly commonly seen flying about, visiting flowers, and is essentially a pest of young plants.

Shining greenish yellow eggs are laid singly on the tender leaves of the plant. The caterpillars in their initial stages are dark in colour resembling almost the droppings of birds. They feed voraciously on the foliage and turn greenish as they grow. They have a peculiar habit of projecting out a horn like process from the

Plate 127.—*The fruit sucking moth*—Ophideres *sp.* P. 959

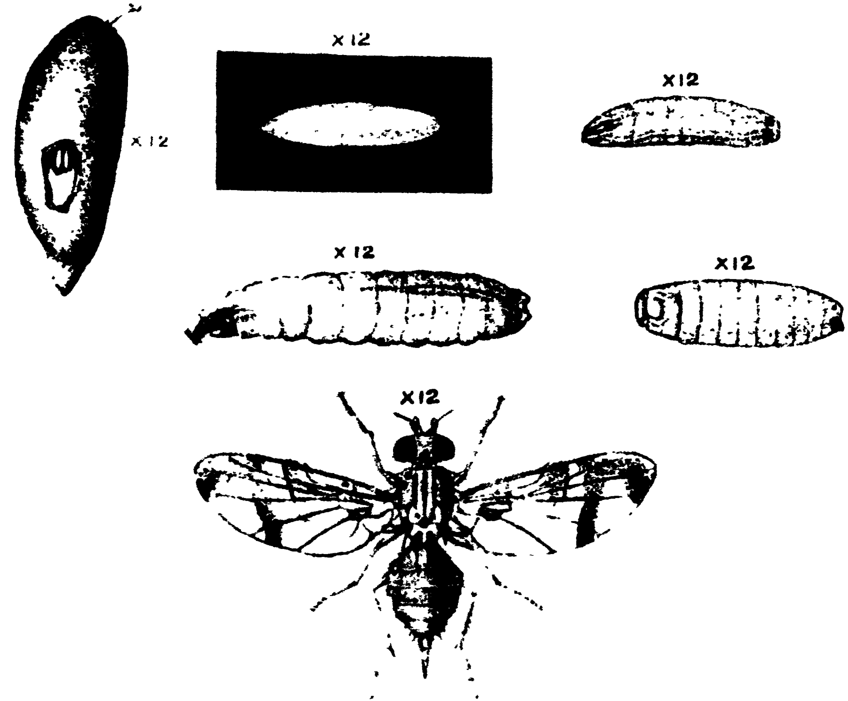


Plate 128 — *The ber fruit fly* — Carpomyia vesuviana, *B.*

head and emitting a deterrent smell when disturbed. The full grown caterpillar which is about $1\frac{1}{2}$ inches in length changes itself into a naked chrysalis and is attached to the plant by a fine silken girdle. The adult emerges in about ten days. Besides citrus, the larvæ are also found on other Rutaceous plants, woodapple, Murrayia sp. and sometimes on Bilwa—*Aegle marmelos*—also. The eggs are parasitised by some minute wasps and the caterpillars by *Apanteles papiliotes*, V.

Control measures.—The eggs are fairly prominent when laid on the young unopened leaves and can, therefore, be handpicked. In severe cases, arsenical sprays may be tried. Recently BHC has also given encouraging results.

The ber fruit fly (Carpomyia vesuviana, *B*).—This fly was recorded as a serious pest of the finer varieties of the ber fruit as early as 1936. The adults occur by July and later lay their eggs inside the half-mature fruits by August. The maggots hatch out in two or three days, feed on the pulp and ruin its quality. They get full-grown in about 13 days and then drop down to the soil and pupate at a depth of 2 inches to 3 inches. Two braconids *Bathyaulax carpomyiae Ram* and *Opius* (*Boisteres*) *carpomyiae S.* have been reared out from the maggots. Another pinkish caterpillar—*Meridarches scyrodes M.* is often found to cause a similar damage. The fly being the major pest attention was concentrated on its control from the very early days. Sprays poisoned with Sodium fluosilicate, arsenical compounds, etc., were first tried with no appreciable relief. Attempts to trap the adults on chemotropic principles using essential oils like lemon grass oil, citronella oil, Clensol, etc., were also equally unsuccessful. Raking up the soil under the trees down to a depth of three or four inches was advocated as a palliative to destroy the pupae. More recent trials with BHC and DDT sprays have shown the adaptability of the latter at 0·1 per cent as a definite measure of control against both these borers. The total expenditure for four rounds of sprays works out to 13 annas per tree and the money value of the additional yield is computed to be Rs. 11–11–0. BHC., though equally effective, was found to impart its peculiar odour to the fruits.

The sapota leaf webber (Nephopteryx eugraphella *R*).—The pest breeds on tobacco, *Mimusops elengi* and sapota and was very serious at Coimbatore during 1938 and 1941.

The larvæ bore into the tender buds and fruits and web the leaves together. The leaves are scraped and eaten, eventually reducing them to a papery skeleton. The formation and development of the fruits is hampered considerably.

The female lays her yellowish oval eggs either singly or in groups of two or three on the silken strands connecting the leaves or on the leaves near the mid rib. The caterpillars hatch out in three to five days, feed on the leaves and buds and attain full

growth in about 17 to 32 days. The full grown larva constructs a cocoon of silk and frass within which it pupates and emerges as adult in seven to eleven days.

A Braconid larval and a Chalcid pupal parasite have been recorded.

Control.—Spraying with Calcium arsenate was found to be fairly effective. Removal and destruction of all the infested material may help to minimise the damage. Spraying with BHC and DDT at 0·1 per cent has given good results.

The grapevine flea beetle—(Scelodonta strigicollis, *M.*).—The cultivation of the vine is almost the only source of livelihood for a certain class of people in parts of Salem, Anantapur, and Madurai districts. The cultivation is being extended rapidly in the other districts, chiefly on account of the attractive prices the fruits fetch. But among the factors which hinder its rapid spread, the damage by the flea beetle is a major one. It is an active coppery brown insect about 1/3 inch in length often occurring in numbers and defoliating the tender shoots. (Plate 129.)

Mere collection of the adults with hand-nets and use of arsenical poisons were suggested so far. A definite control has been achieved recently by the use of either BHC or DDT spray at 0·1 per cent concentration.

The pomegranate butterfly (Virachola isocrates, *F*).—Pomegranate was commonly grown till recently round about Tirupur and Coimbatore. But its cultivation is, of late, being given up and the gardens are either abandoned or the trees cut down, mostly due to the ravages of this butterfly against which the owners are practically helpless. Occasionally the insect also attacks other fruits like guage, apple, Sapindus, etc. (Plate 160.)

The butterfly lays her shining whitish eggs singly on the surface of the fruits and the caterpillars, on hatching out, bore into the fruit ruining the entire contents. The full-grown caterpillar is stout, about ¾ inch in length and is sparsely covered with hairs. Pupation takes place inside the fruit itself.

Control.—Simple measures like collection and destruction of the infested fruits and screening or bagging the healthy ones were suggested but none of these can be assiduously adhered to by the growers. Recent trials with BHC and DDT sprays at regular intervals have given some indicative results, but the experiments could not be pushed to conclusive results as the pest was practically absent during 1950.

The cockchafer beetle (Melolonthidae).—These are heavy-built beetles of various hues and are attracted to lights in large numbers during certain seasons of the year. Eggs are laid at a depth of two to three inches below the soil. Fleshy white grubs, with large brown head, wrinkled and curved body, hatch out and feed on the roots causing considerable havoc. The adults are nocturnal in

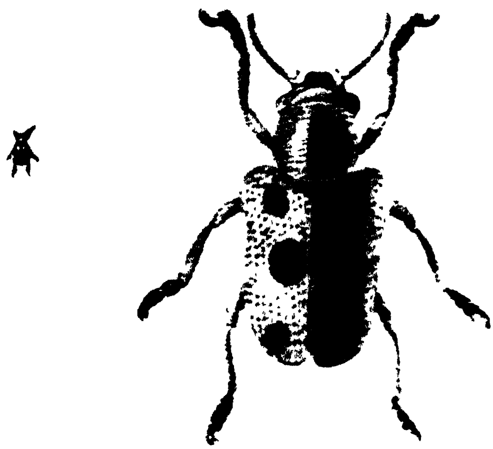


Plate 129.—*The grape vine flea beetle* – Scelodonta strigicollis, *B*. P. 963

Plate 130. *The pomegranate butterfly*—Virachola isocrates, *F* P. 964

habits and are equally destructive as they nibble at the leaves of plants. The entire life history takes about one to two years. On the Nilgiris, their depredations are well-known and commence by August, ending by January. Trials to control this pest by setting up light traps to attract the adults, flooding, ploughing, application of soil fumigants round the plants to kill the grubs gave only partial relief. A heavy incidence of these grubs on strawberry was warded off by the timely application of BHC D·025. The soil round the plants was dug up to a circumference of about nine inches. BHC D·025 was sprinkled in and the soil covered up. A cent per cent mortality of the grubs was noted in about 24 hours. The calculated cost is about Rs. 40 per acre.

Pest of cashew.—Cashewnut has, of late, been in great demand, in the hard currency areas like America and is, therefore, contributing in its own way to earn the dollar currency so very necessary to stabilise our national economy.

The chief pests of this crop are the thrips *Selenothrips rubrocinctus* G. which is also recorded on Cacao in Ceylon and the bug—*Helopeltis antonii S*. The water scale *Ceroplastes floridensis C* also is occasionally seen on this fruit tree. The wild silk moth—*Cricula trifenestrata H* is a sporadic but serious pest. No special work was done towards the control of these pests but the methods suggested for similar pests on other crops can as well be adopted with advantage.

The cashew Cerambycids (Plocaederus ferrugineus, *var*, niger G, P. consocius, *P*.—These longicorn beetles cause considerable havoc to these fruit trees on the West Coast. The adults are big sized, dark-brown insects, possessing the characteristic pair of long feelers. They emerge generally late in the evenings after some sharp showers. The eggs are laid on the bark and the grubs on hatching tunnel into the tree-trunk in different directions on the main stem, often extending down to the roots as well. They feed on the cambial layer and a thick reddish mass of chewed fibre and their excreta are thrown behind in the tunnels. The infestation can be detected by the exudation of small quantities of a reddish fluid from the bore-hole. Badly infested trees produce a slightly hollow sound when tapped gently with a stick. The later indications are that the leaves turn yellowish and drop and the tree itself dies eventually. The grubs continue to feed on the trees even after its death, and as many as 250 of them have been counted inside a single trunk. The full grown grub is fleshy, stout, creamy white in colour, about two inches in length. Pupation takes place inside a cocoon made of some calcareous matter probably Calcium carbonate.

Control.—With the imperfect knowledge on hand regarding the pest, it is difficult to suggest any feasible method of control. Individual grubs may be removed mechanically, if their presence inside the tree is detected in time. Badly damaged trees should be cut down and used as fuel immediately. The adults which are

slugggish in habits can be caught as they emerge late in the evenings and killed. No natural enemies or alternative host-plants have been recorded so far.

7. SUGARCANE.

Sugarcane is one of the most important industrial crops of this State and its cultivation is practised on a large scale in the districts of Visakhapatnam, Godavari, Bellary, North and South Arcot and Coimbatore.

This crop also has its own insect enemies to contend with, the more important forms being the early shoot borer—*Argyria (Proceros) sticticraspis*, H., the cane borer—*Diatræa (Proceros) venosata*, W., the top shoot borer—*Scirpophaga* sp., the cane leaf-hopper—*Pyrilla perpusilla*, W., the rice grasshopper, *Hieroglyphus banian*, F., and two species of termites.

The borer pests have been under study from the very inception of the section. Considerable spade work has been done on their habits and tentative measures like application of arsenical poisons, sodium fluosilicate, etc., were tried off and on. Research was further concentrated on the detailed life history of the three species and their natural enemies, alternate hosts, etc., from the year 1935 onwards up to 1942 and some interesting results were obtained. In spite of these endeavours, the control of the borers still remained as elusive as ever. A comprehensive scheme of research was, therefore, initiated by about 1942 at Coimbatore and Nellikuppam in South Arcot district. The scheme was financed by the Imperial Council of Agricultural Research up to 1945 and was later taken under the aegis of the Indian Central Sugar Committee. The main lines of research on the fundamental side are studies on the influence of the climatic and weather factors on the borer population, mortality and compensation indices, alternative host-plants, natural enemies, etc. On the economic side the trial of the egg parasite—*Trichogramma*—constituted the main item. A few other methods like earthing up of the young plants against *Argyria*, digging out crop residues, spike thrust, insecticidal trials, etc., were also investigated. The biological control trials were discontinued in March 1950 at Nellikuppam and work on the fundamental aspects is being continued at Coimbatore. A gist of the results is furnished below.

The early shoot borer (Argyria sticticraspis, H.).—The moth is a small straw-coloured insect. It is essentially a pest of the young crop and makes its appearance almost along with the sprouting of the buds by April–May and continues its damage till June–July. The caterpillars bore into the young tillers causing withering and eventually their death. In some cases, the incidence of the pest is supposed to be a blessing in disguise for the reason that it induces profuse tillering but this cannot always be an advantage as it may ultimately lead to the late maturity of the crop. The pest disappears by June–July, but may occasionally be seen on the developing canes also.

The female lays her pale, scale-like flattish eggs in batches on the leaf surface and the caterpillars on hatching out, bore into the shoots. The full grown caterpillar is about an inch in length and pupation takes place inside the stem itself. The egg stage extends for about three to four days, the larval for about a month and the pupal period about ten days.

Alternative hosts.—Negligible numbers of the caterpillars have occasionally been recorded from *Saccharum spontaneum* and also on *Pennisetum hockenhackeri* during 1946–47.

Natural enemies.—The natural enemies of this pest comprise of the egg parasite—*Trichogramma minutum* R. (Chalcidae) and *Telenomus beneficiens*, Z. (Scelionidae) and two larval parasites—*Stenobracon* sp. and *Apanteles flavipes*, C.

Control.—The possibilities of an intensive colonization of the egg parasite—*Trichogramma*—were fully investigated against *Argyria* at Nellikuppam for the past seven years. The parasites were bred at Coimbatore on a mass scale on the eggs of *Corcyra cephalonica*, H. and the parasitised egg cards despatched to Nellikuppam by post. The adults were released in the cane fields on their emergence. The plots were each three acres in extent situated sufficiently far away from one another with an adequate number of replications and control and the variety of cane grown in these plots was Co. 349 except for one year. Two sets of experiments, one with six weekly liberations and the other with twelve, at the rate of 8,000 parasites per acre were conducted till 1946. As the results were conflicting, the releases were modified by 1947 to only one set of twelve liberations at 16,000 parasites per acre. Fortnightly data regarding the egg parasitization, borer infestation and borer population were recorded and the yield also was finally assessed at harvest. Increased aggregate parasitism ranging from 13 per cent to 36 per cent was in evidence in the treated plots. Borer infestation was reduced by 8 to 32 per cent and the trends of the population were more or less parallel. During the seven years of experimentation, the additional yield of the treated plots ranged from 2·78 tons to 10·35 tons per acre for five seasons and the results were negative during two seasons only. In spite of the apparently encouraging data, the interrelation between the different aspects of study were not statistically significant. This line of work was, therefore, closed by March 1950 with the general and broad conclusion that the colonization of the parasites increases the degree of field parasitism.

Earthing up of young plants with a view to smother the egg masses as well as the young caterpillars of *Argyria* was tried. The variations in the reduction of the incidence ranged from 8 per cent to 53 per cent in the treated plots, during the three years of trial. Proportionate increases in the yield were also recorded but the figures were not statistically significant. Digging out the crop residues was conducted for a period of three years with a view to eliminate the breeding ground of the borers during the offseason

and incidentally to augment the yield as well. The method appears to be within the economic limits of the ryot since the calculated net profit by this treatment alone ranged from Rs. 21 to Rs. 91 per acre. But certain limitations like its impracticability in clayey soils and the scarcity of labour during the harvest season render it unworkable. Spraying with DDT and BHC were also tried but the results were conflicting. The mechanical destruction of the larvae by inserting a thin stiff wire into the central shoot was found equally impracticable.

The cane borer [Diatroea (Proceros) venosata, *W.*].—The activities of this insect are restricted to the well formed canes. The pest appears by July–August and progressively increases in its virulence up to the harvest stage. The caterpillars bore into the cane and in bad cases affect the juice quality. The colour and size of the adult as well as the life-history details are more or less the same as in the case of the shoot-borer, but the caterpillars have definitely a roving habit. Feasible methods of control have yet to be evolved.

Alternative hosts.—The pest has been found to feed on *Saccharum spontaneum* and maize in South India, and on Sorghum, Ikri, Bajra and Sudan grass in North India.

Parasites.—The eggs are parasitized by *Trichogramma minutum* R. and *Telenomus* sp. (Chalcidae), *Stenobracon deesae* C., *Rhaconotus roslinensis* Lal, *R. scirpophagae* Wlk, *Apanteles flavipes* C. (Braconidae), *Goniozus indicus* A., and *Xanthopimpla nursei C.* and *Pimpla* sp. (Ichneumonidae) are found to keep the pest in check in its larval stage. The pupae are attacked by two Eulophid parasites—*Tetrastichus ayyari* Roh. and *Trichospilus diatroeae* (MS). A fungus—*Isaria* sp.—has been noted on the larvae at Coimbatore.

The top borer (Scirpophaga sp.).—The moth is characterized by its pure white wings with an orange coloured tuft at the end of the abdomen. The eggs are laid in small masses on the leaves and are differentiated from those of the other species by the presence of a buff-coloured hairy covering over them. The caterpillars bore into the cane but confine their activities to the terminal regions, causing the characteristic bunchy tops. The pest is not serious in South India. (Plate 131.)

Natural enemies.—*Tetrastichus*, sp. (Eulophidae) and *Telenomus beneficiens*, Z. and *T. rowani* (Scelionidae) have been observed as egg parasites. Among the larval species may be mentioned *Stenobracon nicevillei*, Bing, *S. deesæ* C. and *Rhaconotus scirpophagae*, Wlk (Braconidae), *Elasmus zehntneri*, F. (Elasmidae) *Goniozus*, sp. (Bethylidae) and *Shirakia*, sp. A few species of small ants and spiders also feed on these insects.

Alternative hosts.—*Saccharum spontaneum* has been found to harbour these borers in South India.

The cane leaf-hopper (Pyrilla perpusilla, W.).—This is a Fulgorid bug with straw coloured wings and a prominent snout. It occurs practically in all the sugarcane areas, but is generally chronic

Plate 131.—*The top borer of sugarcane*- Scirpophaga, *sp* P. 969

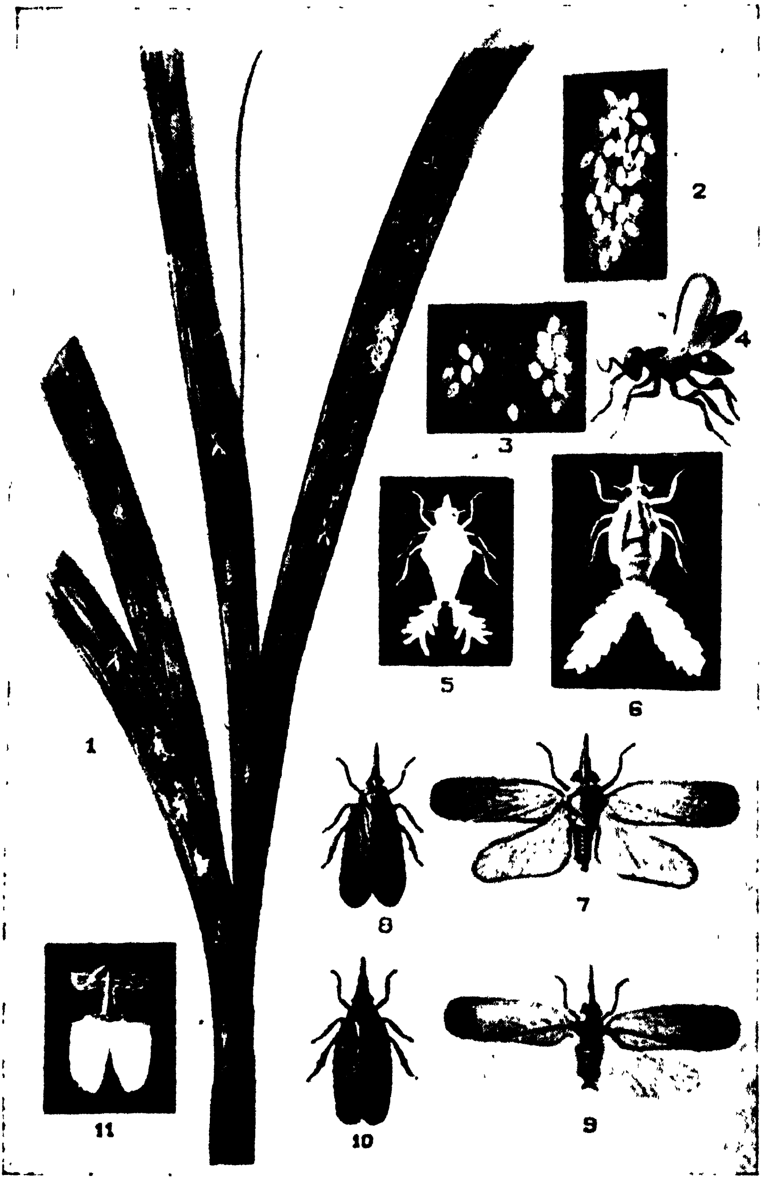


Plate 132 —*The cane leaf hopper*—Pyrilla perpusilla, W. P. 970

in parts of the Northern Circars, South Kanara and occasionally in parts of Coimbatore and South Arcot. During bad seasons millions of the bugs appear in swarms and the crop loses its vigour and looks sickly due to the enormous drain on the nutritive material. The adults and young secrete large quantities of a sweetish fluid on which the fungus—Sooty mould—develops, making the plants look all the more unsightly. (Plate 132.)

Batches of greenish yellow eggs are laid on the undersurface of the leaves and covered by a mass of fluffy material. Nymphs hatch out in due course and are characterized by the presence of the two tail like processes. The total life cycle extends up to two months. A Dryinid wasp—*Dryinus pyrillae*—and a species of chalcid parasitise the nymphs and the eggs respectively.

Control.—A severe incidence of the pest was experienced at Nellikuppam during 1932 and again at Coimbatore and South Kanara during 1947–48. At Nellikuppam, efforts were made to control this pest by spraying kerosene oil emulsion, setting up of light traps, bagging with hand nets and collection of egg masses. The first two methods were practically useless, while a certain amount of relief appears to have been achieved by the latter two. Even here, the intrinsic value of the control methods has been practically very little, since the check which was effected at an enormous expense was very soon neutralized by the invasion of the bugs from the surrounding untreated areas. BHC D 025 was tried for the first time at Coimbatore in 1947. The bug, which was bad on about seven acres was practically exterminated with one application. Hexyclan 5 per cent—another BHC product—was tried in South Kanara with similar effects. The quantity of chemical required to dust an acre may be from 20 lb. and above depending upon the severity of the pest and the stage of the crop.

The cane grasshopper (Hierogrlyphus banian, *F.*).—The same species mentioned under rice takes to sugarcane also in parts of Northern Circars during certain years. The methods of control advocated till recently were the same as for the leaf-hopper but with a greater stress on efficacy of organized beats, use of hand nets, etc., but as in the case of most of the mechanical methods, complete extermination was not possible. BHC D 025 was first tried at Bobbili and the results were spectacular. The chemical is since being used on a large scale by the ryots. For natural enemies, alternative host-plants, etc., please refer under ' Rice '.

Termites.—Two species *Odontotermes obesus*, R. and *Eutermes haemi*, W. have been recorded to be occasional pests of sugarcane. The former devours the entire contents of the setts below the ground, while the latter is more a leaf-eater. The best method would be to destroy termite mounds, if any, in the near vicinity. Mixing crude oil emulsion or tar emulsion in irrigation water may be adopted as a palliative in cases of bad attacks. Application to the soil of BHC or DDT is proving useful.

8. COTTON.

Cambodia cotton is subject to damage by a number of insect enemies of which the bud and bollworms and the stem weevil are the more important, besides the leaf jassid more recently flaring up into prominence. The study of these pests has been one of the earliest items to be investigated by the section from the year 1912 onwards.

The bollworms.—These comprise of two categories, viz., the spotted bollworms—*Earias insulana*, B. and *Earias fabia*, S. and the pink bollworm *Platyedra gossypiella S*. The former attack only the shoots and buds and hence are not of much importance. The pink bollworm—*Platyedra gossypiella*, S. on the other hand is more serious and occurs all over the State. As the name suggests, the caterpillars are pink in colour and cause considerable damage by boring into the green bolls, kapas, seeds, etc., and ruining the contents (Plate 133).

The adult is a small, blackish brown moth and lays her small flat eggs singly on the tender leaves, flower buds, etc. The caterpillars hatch out in three to four days and bore into the bolls. They get full grown to a length of about half an inch in about three weeks and pupate inside. The adult emerges in about ten days. The caterpillars also attack the seeds during the later stages and a fairly good percentage of them have been noted to undergo what is known as the larval diapause stage. The pest being of all India importance, a good amount of work has been done on the life-history and habits of the pest and a fund of literature is available.

Alternative hosts.—The spotted bollworm breeds also on *Abutilon indicum*, *A. hirtum*, *Hibiscus rosasinensis*, *H. cannabinus*, *H. esculentus*, *H. vitifolius*, *Malvastrum coromandelianum*, *Althoea rosea*, etc. The caterpillars have a special partiality for the pods of *Hibiscus vitifolius*. The pink bollworm, on the other hand, usually confines its activities to cotton and is occasionally found on *Hibiscus cannabinus*, *H. vitifolius* and *H. esculentus*.

Parasites and predators.—The spotted bollworms are subject to field prasitisation by a number of wasps like *Microbracon lefroyi*, D and G, *M. greenii* Ash, *M. hebetor* Say, *Rhogas aligharensi* Q, *Bassus*, sp, *Elasmus johnstoni*, F, *Melcha nursei*, C, *Polydaspis compressiceps*, D. and also by a tachinid fly—*Actia hyalinata* Mall. The pink bollworm has its own parasite complex, most of them being larval forms. They consist of *Apanteles pectinophorae* and *Microbracon gelechidiphagus* Ramk, *Chelonus* sp and *Goniozus*, sp. Possibilities of biological control with the help of the egg parasite—*Trichogramma minutum* R—are also on record.

The stem weevil (Pempherulus affinis, *F.*).—This ranks almost equal to the pink bollworm in its status as a pest. The adult is a tiny, brown weevil, one-eighth inch in length. The injury is caused by the grubs boring into the stem and causing prominent

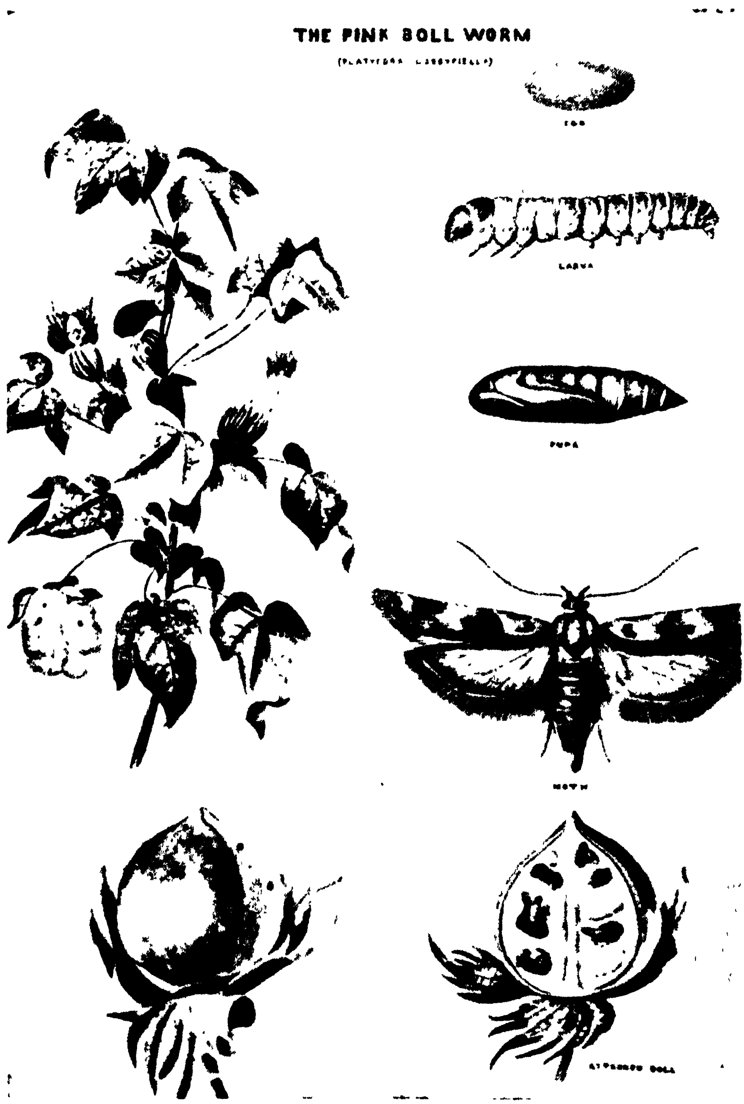


Plate 153.—*The pink boll worm*—Platyedra gossypiella, *S.* P. 973

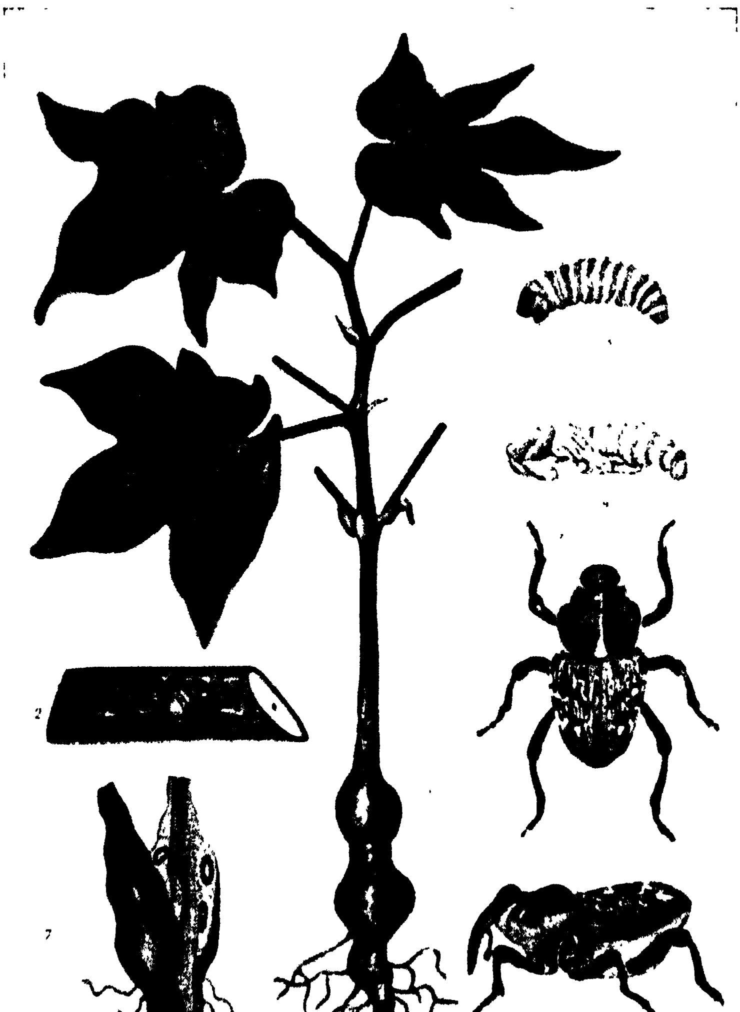


Plate 134.—*The cotton stem weevil*—Pempherulus affinis, *F*. P. 974

swellings generally at the lower portions of the plants. Young seedlings invariably succumb to the attack and the grown up plants, though they survive, lose their vigour and often lodge, snapping at the swollen portions. The pest has been under intensive study from the very inception of the section but the damage caused has been so serious and widespread that it warranted more detailed investigations under one or two special schemes. One such scheme was sanctioned by the Indian Central Cotton Committee to study the distribution of weevil in India both in cotton and its alternative hosts, in conjunction with a search for parasites and predators. The scheme was initiated by October 1935, and continued to function under the Cotton Specialist for a period of four years. The work was further continued under the Government Entomologist for another period of one year and three months when it was finally closed in 1941. A fund of information has accumulated during the course of the studies and a resume is given below (Plate 134) :—

The parent deposits her shining white eggs singly under the surface of the stem. The grubs hatch out in about nine to eleven days and bore inside. The larval stage extends from 30 to 45 days and the pupal ten to twelve days.

Alternative host plants.—Special attention has been paid to this aspect and the weevil has been found to breed on a variety of wild and cultivated plants, viz., *Triumfetta rhomboidea*, *Corchorus Olitorius*, *Corchorus trilocularis*, *Sida acuta*, *Sida spinosa*, *Sida glutinosa*, *Sida rhombifolia*, *Malvastrum coromandelianum*, *Hibiscus vitifolius*, *H. ficulneus*, *H. esculentus*, *H. cannabinus*, *H. surattensis*, *Urena sinuata*. *Melochia corchorifolia*, *Abutilon indicum*, *Abutilon hirtum*, *A. glaucum*, *Thespesia* sp. etc. Of these plants, *Triumfetta rhomboidea* seems to be the most favoured of the wild plants.

Parasites.—One of the interesting aspects which came to light is that the grubs are parasitized exclusively by certain species when it breeds on the alternative host plants, while a few others have been found to be specific on it when it attacks cotton. The species recorded in association with cotton are *Spathius critolaus*, N., *Euderus pampheriphila*, R and M, *Eupelmus*, sp. *Aplastomorpha calandrae*, H. *Eupelmus urozonus*, D, etc. A mite *Pediculoides ventricosus Newpt*—has been found to be predatory on the larvae. Some work was done on the first mentioned species but its potentialities could not be put to a critical test under field conditions.

On the grubs breeding on alternative host plants, *Entedon pempheridis*, F., *Dinarmus sauteri*, M., *Eupelmus urozonus*, D., and *Euderus pemperiphila*, R. and M. and *Spathius labdacus*. N.. *S. critolaus*, N., *Rhaconotus cleanthes*, N. and R. *menippus*, N., have been recorded as parasites. A nematode parasite—*Geomermis indica*, St. has also been noted.

Besides these, a number of parasites attacking allied weevils in North India have been tried against this one, but no tangible results were forthcoming.

Control measures.—The control of the two pests on a crop which is grown on so vast a scale presents a very knotty problem. The only feasible method was the rigorous application of some measure by which the pest could be starved out of their natural food. The provisions of Pests and Diseases Act, 1919, were applied in respect of this pest, and the removal of all the cotton plants by about a month before the sowing of the succeeding crop was enforced as early as 1919. The enforcement of the Pest Act, besides achieving the object in view, has stamped out the pernicious practice of indefinitely ratooning the crop, which in its turn allowed the insect pests to breed in their millions and serve as a perpetual source of infestation. Enquiries go to show that the enforcement of the Pest Act has resulted in definitely improving the quality of the cotton and it is, therefore, still kept in force.

The cotton jassid (Empoasca devastens, *D.*) :—These jassids popularly known as leaf hoppers form another serious pest of the exotic varieties of cotton, probably assuming as much magnitude as the other pests during certain years. These bugs have been under investigation for the past 40 years by Entomologists as well as the Cotton breeders all over India

The adults and their young occur in their millions from November to January and practically ruin the crop by sucking the nutrition. The leaves develop a crinkled appearance, sometimes assuming a reddish colour. The growth of the plant is retarded and the yield reduced to practically nothing. The eggs are thrust singly into the soft tissues and the nymphs hatch out in five to fifteen days. They attain the adult stage in about ten to twelve days. The adults live from 36—48 days. The comparatively long lease of life, the high prolificity as well as the short life-cycle of these bugs enable them to multiply rapidly and complete two or three generations during the vulnerable stage of the crop.

Alternative host plants.—Besides the indigenous and exotic cottons, the jassids occur in a severe form on bhendi, *H. esculentus*, *brinjal—Solanum melongena*—Sun flower—*Helianthus annus*—Hollyhock—*Althoea rosea*—and potato—*S. tuberosum.*

Attempts to control this bug with sulphur, lime-sulphur, tobacco, kerosene oil emulsion, bordeaux mixture, etc., have met with very little success. More tangible results have been achieved by the Cotton Specialist, Coimbatore, in breeding jassid-resistant strains where the degree of hairiness of the leaves is one of the factors associated with the resistance.

Recent trials with DDT as dust and spray have indicated a solution for the problem. The chemical has been highly effective in both the forms, but the spray at 0·1 per cent concentration is more efficient and economical. Hexa-Ethyl-Tetra-Phosphate a new insecticide has shown considerable promise against these jassids.

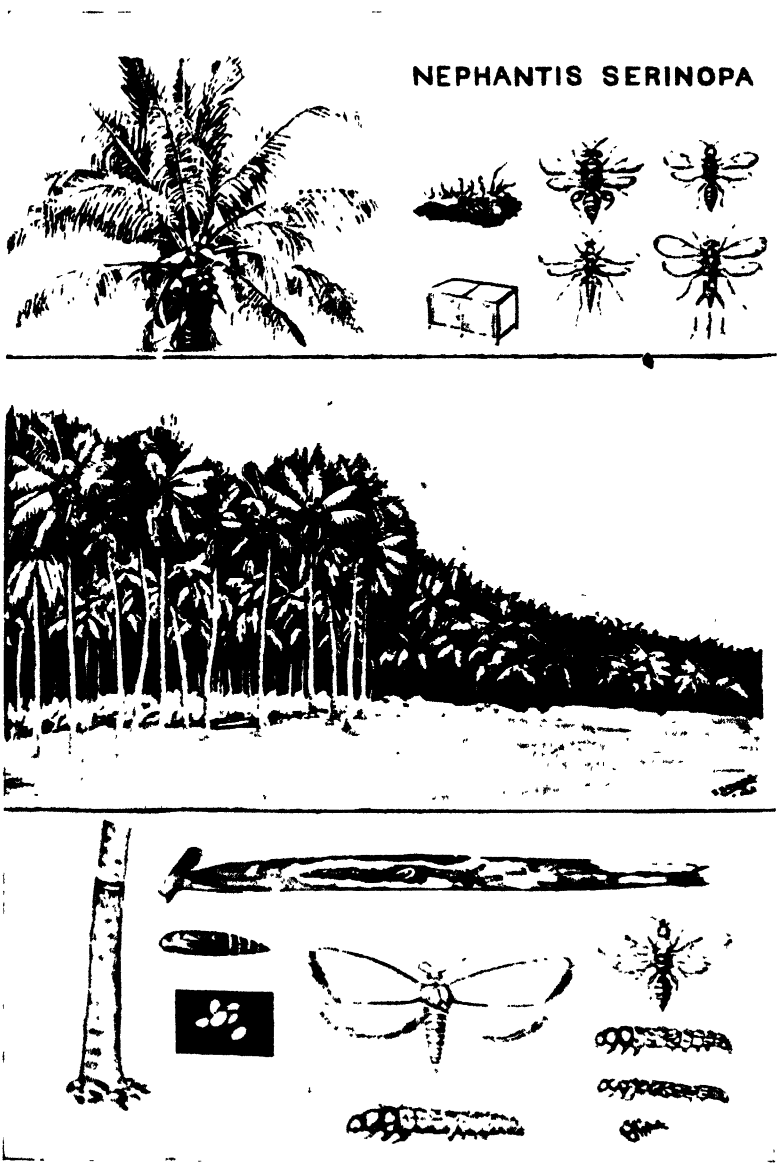
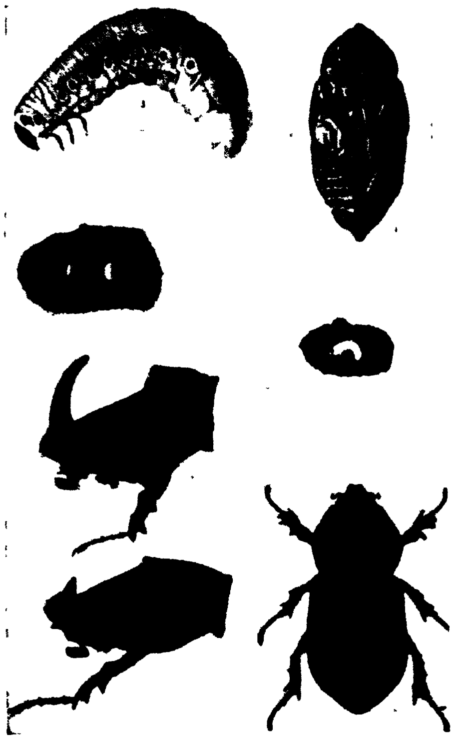
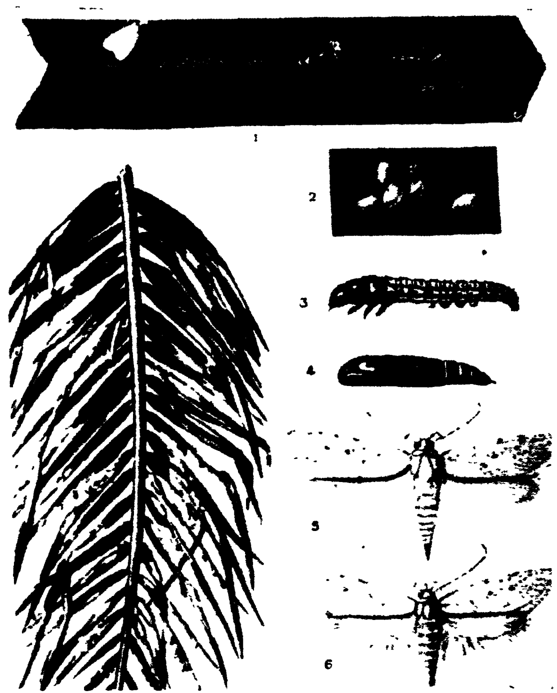


Plate 135.—*The black-headed caterpillar*—Nephantis serinopa, *M.* P. 977



(1)

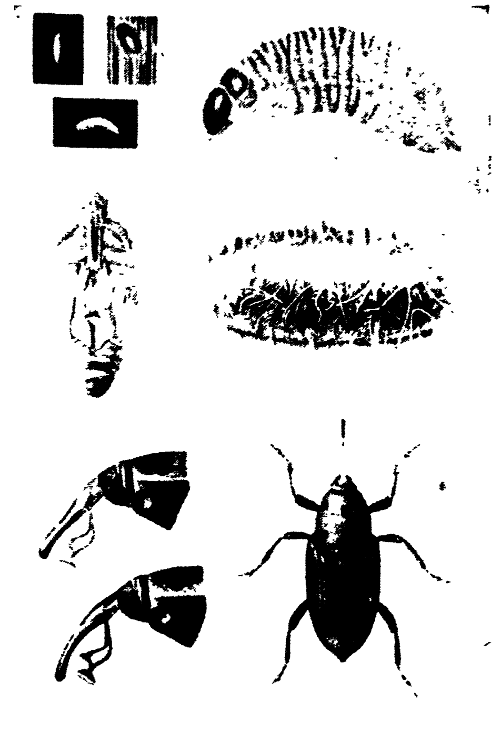
A. Rhinocers Boeetle



(2)

Plate 135 (*a*) — *Important pests of the coconuts*

B. Black-headed caterpillar.



(3)

C Red palm Weevil.

The cotton aphis (Aphis gossypii, *G.*).—Exotic varieties of Combodia cotton often suffer severely from these aphids. Colonies of these dark-brown minute insects establish themselves on the tender portions of the plants and leaves, suck the plant sap and cause the wilting of the shoots. Severe infestations are characterised by the secretion of appreciable quantities of honey-dew and a number of species of bees, wasps, flies, ants, etc., visit these colonies for the sake of this sweet liquid. Occasionally a 'sooty mould' also develops on this stick secretion and the plants present a blighted appearance. These aphids are invariably attended by their natural enemies, the more important of which are a few species of lady-bird beetles and their grubs (*Chilomenes sexmaculata*, R.) and maggots of syrphids (*Xanthogramma scutellara*, F.) and lace-wing flies (*Chrysopa*, sp.). These predators generally exert a considerable influence on the natural control of these aphids.

Control measures.—The approved method is a thorough wash with tobacco spray but the treatment may have to be repeated more than once in cases of severe attack. Recent trials have shown the remarkable efficacy of HETP and BHC sprays and these are likely to supplant tobacco spray very soon.

Among the minor pests of cotton, which occasionally assume a major role are the flea beetle—*Monolepta signata*, *O.* and the thrips—*Thrips tabaci*, L. These invariably occur during the earlier stages of the crop, when it is unable to withstand the damage. The use of arsenical poisons for the former and tobacco decoction for the latter were recommended so far. Recent trials with BHC D 025 have given very encouraging results against both these pests.

9. Oil seeds.

A number of crops come under this category of which the more important are the coconut, groundnut and castor.

Coconut.—The major pests of this crop are (*a*) the black-headed caterpillar—*Nephantis serinopa*, M., (*b*) *the Rhinoceros beetle—Oryctes rhinoceros*, L., (*c*) the Red Palm weevil—*Rhynchophorus ferrugineus*, F., and (*d*) *Rats*—Rattus rattus wroughtoni, H.

The black-headed caterpillar (Nephantis serinopa, *M.*).—This is generally present in a mild form on coconuts and palmyrah, mostly along the East Coast. The pest flared up in South Kanara by about 1921 and had since spread to an alarming degree throughout the coastal belt. The damage is caused by the caterpillars. The adult is a small moth, yellowish white in colour. Eggs are laid in groups on the underside of the leaf, generally near the old larval galleries. The caterpillars hatch out in four to six days, construct tiny galleries out of frass and pellets and feed on the green matter from under the cover. They attain full growth of an inch in about 30 days. The leaflets are deprived of the green matter on account of the continued feeding and their colour is reduced to

that of a mere brownish parchment. Consequently the whole garden presents a scorched appearance when seen from a distance and the yield also is reduced considerably (Plate 135).

Control.—The evolution of the control measures can be dealt with under two broad phases. A systematic cutting and burning was, at first, advocated as an immediate and emergent measure and it was later augmented by biological control as well.

Cutting and burning.—The situation, on receipt of the first report by 1921, was indeed critical and was even deteriorating rapidly, probably due to the singular absence of any of the natural enemies which generally keep such outbreaks in check. Some measure which would mitigate the virulence of the pest had to be immediately thought of and advocated. In the absence of anything better, the only expedient was to recommend a wholesale cutting and destruction of the infested leaves. As the method was crude and laborious, it did not find favour with the garden owners. In the few instances where they could be persuaded, the response was not spontaneous nor was the work conducted anywhere with the required degree of promptness and thoroughness. The provisions of the Pests and Diseases Act, 1919, were enforced over an area within five miles radius of Mangalore by January 1923. The stipulations of the Act made it obligatory on the part of the owners to follow departmental advice for eradicating the pest. A gang of tappers was employed and the progress of clearing the infested gardens was pushed on vigorously under the supervision of special Revenue Inspectors. With the accumulation of experience, it was later decided that the cutting of the entire fronds was not necessary and only the leaflets were shaved off with a billhook specially designed for the purpose. During the initial stages, the cost of the operations was recovered from the ryots but was later borne entirely by the Government. With all the unpopularity inevitable in such maiden legislative ventures, the progress of the work was satisfactory and the overall effects were definitely favourable in the operated areas. The pest had, by this time, spread practically all over South Kanara and Malabar and the Act was, therefore, extended to the two entire districts.

The search for natural enemies (as described subsequently) and the attempts to adopt these insects for biological control having borne fruit by 1926, the aid of these natural agencies also was pressed into service. The parasites were reared in their thousands and kept in readiness in small laboratories established in the localities. Heavily infested gardens were first cleared of the pest by the mechanical method and kept under a careful watch. At the first sign of reinfestation, the parasites were rushed to the spot and liberated with a view to check the secondary infestation in its early stages. The results of these combined operations were obvious by the general decrease of the pest and by the subsequent recovery of the species of the beneficial insects liberated in the area. As the latter had to be conserved at any cost, the cutting and burning

technique had to undergo a further modification. Infested leaves showing indications of parasitism were kept enclosed in cages, specially designed to allow the escape of the parasites while the moths were detained inside. With the evidence on hand, it was concluded that a proper host-parasite ratio has been established in the field and the work was, therefore, closed subsequently in 1931, with the hope that the artificial balance of life would be kept up by nature.

Parasites, their initial collection and later adaptation.—While the control operations were in full force in the West Coast, exhaustive surveys were conducted along the East Coast in all the palmyra and coconut areas for the natural enemies of *Nephantis serinopa*, as there was reason to believe that the pest has been prevalent there for a long time and was probably kept in check by its natural enemies. Ten species of the parasites and predators enumerated below were found to occur in these areas :—

Apanteles taragamæ, V. ..	Braconid.	Larval parasite.
Perisierola nephantidis, M. ..	Bethylid.	Do.
Microbracon brevicornis, W. ..	Braconid.	Do.
Elasmus nephantidis, R. ..	Elasmid.	Do.
Stomatoceros sulcatiscutellum, G.	Chalcid.	Pupal parasite.
Xanthopimpla punctata, F. ..	Ichneumonid.	Do.
Triphleps sp.	Anthocorid bug.	Egg parasite.
Sphedanolestes aurescens. D...	Reduvid bug.	on egg and larvæ.
Parana laticincta, B.	Carabid.	on larvæ.
Winthemia sp.	Tachinid.	pupal parasite.

It must also be mentioned here that the Eulophid pupal parasite—*Trichospilus pupivora*, F.—which subsequently proved to be quite an efficient agency, was later collected from Cochin for the first time. Work regarding the life-history and habits of these forms, their practical efficiency, adaptability for rearing under laboratory conditions, their range of alterative hosts, ability to thrive successfully under field conditions, freedom from hyper-parasites, etc., was pursued further. Only *Perisierola nephantidis*, M. and *Trichospilus pupivora*, F. stood the critical tests at the first instance. Available specimens of these were collected and despatched to the temporary laboratories which were already installed in the infested localities. The parasites were expeditously multiplied in the sub-stations for liberation in the localities desired. The technique of mass rearing was very soon perfected and the adaptability of *Trichospilus*, sp. to a variety of lepidopterous pupae constitutes an interesting finding. A more recent development is the large scale rearing of *Microbracon serinopæ* Ramk, on caterpillars of *Corcyra cephalonica*, H. Adequate stocks of these three species are always maintained in the Section and nucleus consignments are being supplied to the infested localities. As already mentioned, the concerted efforts of the mechanical destruction of the infested leaves coupled with the intensive colonisation of the parasites for over nine years had reduced the pest within controllable limits in the West Coast by 1931, and the work was, therefore, closed subsequently. After a period of comparative lull for about ten years, the pest again flared up in the West Coast during

1941 and the breeding and liberation of the parasites was again initiated with the help of a special staff. The work was discontinued after a certain amount of relief was obtained. Cutting and burning of infested leaves has not since been advocated, as such drastic methods are not always palatable to the public especially when they are enforced with the aid of legislation.

Subsequent outbreaks of the pest, reported from Salem, Coimbatore, etc., were promptly dealt with. Another alarming report was received from the East and West Godavari districts in 1947. Two sub-stations were immediately opened at Narsapur and Razole and two assistants with the necessary staff were stationed at these centres. Breeding and liberation of parasites were commenced forthwith and the results have been highly satisfactory.

The Rhinoceros beetle (Oryctes rhinoceros, L.).—This is one of the serious pests of the coconut palm occurring in most of the tropical regions and is equally bad in almost all the coconut growing tracts in this country also. The bettle is a stout, well-built insect, dark in colour with a characteristic horn on its head. The adult burrows into the soft regions of the crown and feeds on the growing tissues. Indications of the damage are exhibited by the characteristic clipping of the leaflets and in serious cases the entire crown is deformed and seedlings, if attacked, invariably succumb. (Plate 136).

The beetles breed in manure pits feeding on the decaying vegetable matter. Eggs are laid on the food material from which the grubs hatch out in due course. The full-fed grub is thick, fleshy and creamy white in colour and two to three inches in length. Pupation takes place inside an earthen cocoon at a depth of one to three feet from ground level. The total life-cycle from egg to adult has been found to extend from three and a half to eight months.

Alternative hosts.—The beetles take to palms of various species such as palmyrah, talipot, date and African oil palms, American aloes, sugarcane, agave and occasionally pineapple also, particularly when coconut palms are not available nearby.

The pest has very few natural enemies to contend with except for a species of mite—*Uropoda* sp—and the green muscardine fungus—*Metarrhizium anisoplioe*. Ants also have been noted to feed on the grubs.

Control measures.—The beetles can be removed from the trees with a barbed hook (Plate 137). A certain amount of relief is also claimed by packing the axils of the leaves with a mixture of sand and salt. Manure pits suspected to harbour the grubs can be frequently raked up and the grubs picked and thrown out. More recent attempts to control them with the help of the green muscardine fungus were not attended with any appreciable success.

Plate 136.—*The coconut beetle* (Oryetes rhinoceros). p. 953

Plate 137.—Removing the Rhinoceros beetle from the Crown by means of a Beetle hook.

P. 984

Plate 138.—*The hairy caterpillar pest*—Amsacta albistriga, *M.* P. 98

The red palm weevil (Rhynchophorus ferrugineus, F.).—This is a reddish brown, stout, big-sized weevil and occurs all over the State. The adult is not capable of any damage, but the larval stages are spent entirely inside the host. The female lays her eggs singly either on the wounds already present on the tree surface or by scooping out small cavities. Soft whitish footless grubs with a reddish head hatch out in due course and bore into the tree trunk, devouring the entire fibrous contents. The full-grown grubs are about 2 inches in length and pupate inside elongate oval cocoons constructed out of the fibrous matter. In severe cases, the entire trunk is practically riddled by hundreds of these grubs. The weevil attacks also other palms like date, sago, etc.

Control measures.—The control of this troublesome weevil lies in one or two commonsense methods. Cuts and bruises on the trees are the favourable egg-laying spots of the weevils. These should, therefore, be avoided and if present may be painted with some repellent like tar. It is rather difficult to save the infested trees but the spread of the damage can be prevented by prompt cutting and destruction of such trees.

Slug caterpillars—*Parasa lepida*, C., *Contheyla rotunda*, H. and *Natada nararia*, M., often occur on the fronds. The first mentioned one is not generally serious and the second one occurs sporadically in parts of South Malabar and Cochin. The incidence of *Natada nararia*, however, seems to be a regular feature in parts of Godavari, the damage being most severe during summer months. No definite methods of control are feasible. Prompt cutting and destruction of the infested fronds may help in keeping down the pest.

Rats (*The Indian rat*) Rattus rattus wroughtoni. H.).—These rats are sometimes exceedingly destructive to coconuts. Their general coloration is reddish or yellowish-brown with the feet light yellowish. Peculiar nests are built on the trees themselves with the fibrous strands of the leaf-sheaths for breeding purposes. The rodents bite holes through tender coconuts in order to drink the sweet liquid and the spoilt nuts drop down in numbers.

Recently poison baiting with zinc phosphide was found to exterminate the rats.

Groundnut.—*The red-hairy caterpillar* (Amsacta albistriga, M.).—This is a serious pest of most of the dry crops in the red-soil areas and is particularly partial to groundnut. In cases of severe infestation, millions of these caterpillars occur in definite broods and march from field to field leaving a trail of destruction behind. (Plate 138).

Heavy infestation generally occurs from July to September. The full-grown caterpillars seek shady and convenient spots, burrow down to a depth of about 6 inches and pupate there. They remain quiescent till the next summer rains by July on receipt of which the moths begin to develop. The adults emerge exactly on the third day after the next sharp shower and lay their creamy white eggs in small groups the same night anywhere on the nearest

vegetation. The maximum laying capacity of an individual may be upto 1,300. Tiny dark-coloured caterpillars hatch out in three to four days, scrape and feed gregariously on the green matter. They begin to disperse when they are about 10 to 13 days old and march on in numbers in definite directions, devastating every kind of vegetation before them. They attain full growth in about a month, when they turn reddish in colour. They go down to the soil after the next showers and the life-cycle is repeated next year.

Though the pest occurs regularly in most of the dry red-soil tracts of this State, the severity of its incidence appears to be controlled, to a large extent, by the success or otherwise of the periodical showers.

Alternative hosts.—These are polyphagous in habits and do considerable harm to a variety of other dry crops like Bajra, Sorghum, redgram, castor, cotton, etc., not to speak of wild plants like Calotropis, Jatropa, etc.

Natural enemies.—A few wasps and Tachinid flies have been found to parasites the caterpillars and occasionally a disease, probably bacterial, has been recorded to kill them in numbers.

Control.—The pest has been under investigation probably from the very inception of the section. Chemotropic trials with various essences did not give any satisfactory results. The adults are attracted to lights in large numbers and this line of work also was investigated. It, however, transpired later that only males are attracted, the number being proportionate to the intensity of the light. During the period from 1923 to 1929, observations on the effects of a systematic collection and destruction of the moths as they emerge from the soil and subsequently of the egg-masses and the gregarious groups of the young caterpillars also were conducted. In spite of these attempts to nip the pest in the earlier stages, thousands of the adults as well as the larvae were found to escape attention and the grown-up caterpillars had to be hand-picked later. The invasion of the caterpillars from the surrounding untreated areas was guarded against by digging trenches across their line of march and destroying them as they dropped and collected themselves there. The possibility of collecting the pupae also was explored and demonstrated on a large scale. The overall cost of all these operations, when conducted on a co-operative basis, came to Rs. 2 per acre, while the net profit was equivalent to Rs. 25 in the case of Bajra and over Rs. 50 in the case of groundnut, according to the then prevalent rates. This technique has since been passed on as an approved method of control and the provisions of the Pest Act were invoked in respect of this pest in all the areas, where it was prevalent.

Recent research consists in the use of DDT and BHC. The latter, when applied in the trenches as dust, causes an appreciable mortality of the young caterpillars. BHC spray at 0·1 per cent had lethal effects against the grown-up stages. Further trials have shown that BHC dust 10 per cent, Agrocide cotton dust, and Pyrocolloid sprays cause a very high percentage of mortality. In

spite of these interesting results, the use of these chemicals is not likely to find favour in the generally backward and poor dry tracts of the State and until cheaper methods are evolved, the primitive but fool-proof method of hand-picking has to stand.

The groundnut surulpoochi (Stomopteryx nerteria, M.).—The pest has been recorded from the very early days, but detailed investigations were taken up only by about 1942. The larvae mine into the leaves and later web them together and feed on the green matter. Droughty conditions are favourable for the multiplication of the pest. Eggs are laid on the leaves and the caterpillars hatch out in three to four days. The larval and pupal periods extend from 9 to 17 days and from three to seven days, respectively.

Alternative hosts.—This pest also infests Soya beans, red-gram and *Psorolea corylifolia.*

Natural enemies.—Two pupal parasites, *Brachymeria plutellophaga* G. and *Eupelmus* sp. and four larval parasites—*Apanteles* sp. *Microbracon* sp., *Perisierola* sp., and *Chelonus* sp., have been noted so far.

Control measures.—The adults have a strong attraction to light, but their destruction by this method has not yet proved itself to be a definite method of control. Recently dusting with BHC has been reported to give very convincing results.

The groundnut aphid (Aphis laburni, K.).—These aphids are, of late, appearing in a serious form in parts of Ceded districts and Chittoor. Colonies of them occur on the under-side of the leaves and on the stem, causing a severe drain of the cell sap, with the result that the infested plants wilt away. The pest is often kept in check by the activities of predaceous lady-bird beetles. Dusting with BHC D 025 has recently been found successful.

Pests of Castor—*The castor semilooper* (Achœa janata, L.).—This is a specific pest of castor found all over the State. The caterpillars occur in their thousands and completely defoliate the plants leaving only the midribs.

Greenish brown eggs are laid by the female singly on the tender shoots and leaves and the larvae hatch within three to four days. The caterpillars have peculiar semilooping action in their movements as the first pair of prolegs is reduced. A full grown specimen is about 2½ inches in length, smooth, elongate and dull greyish brown in colour, with considerable variations. Pupation takes place either in the soil or in folds of leaves. The life cycle extends to about a month. The adult is a stout moth greyish brown in colour with black blotches on the hind wings.

Besides castor the pest is found on pomegranate, rose and a few Euphorbiaceous weeds as well.

Eggs are parasitised by the Chalcid-Trichogramma sp. A number of Hymenopterous parasites are found attacking the larvae. They are *Tetrastichus ophiusæ* Crwf, *Microtovidea lessonata* Vier, *Hymenobosmina* sp., *Zaminochorus orientalis*, Vier, *Paniscus*

ocellaris Th, *Euplectrus leucostomus* Roh, *Henicospilus* sp., *Rhogas percurrens* Lyle and *Microplitis maculipennis*, Sz. Of these the last mentioned parasite has the peculiar habit of constructing a pillow-like cocoon under the tail end of the host.

Control.—Hand picking and destruction of the caterpillars in mild cases, and treatment with arsenical poisons in bad cases, are advocated. Attempts at biological control with the egg parasite, *Trichogramma* sp. did not yield any conclusive results. BHC 10 per cent is effective against the early stages of the caterpillar.

The castor shoot and seed borer (Dichocrocis punctiferalis, G.).—The caterpillar infests the shoots of young plants and takes to the capsules in a grown up crop. The infested portions are webbed together with silken threads covered by the pellets and some frassy material. The full grown larva is about one to one and a half inches in length and brown or reddish brown in colour. The body surface is covered with short hairs. It pupates inside the stem or the seed capsule. The moth is brownish yellow with dark spots on the wings. Besides castor, the pest is found on turmeric, ginger, guava, peaches, cacoa, mango infloresence, etc. It is fairly serious on cardamom also. Only one *Ichneumonid-Dioctes trochanterata*, Morl., has been found to parasitise the larva.

Control measures.—Only collection and destruction of attacked shoots and capsules can be suggested.

The castor slug (Parasa lepida, G).—See pests of fruit trees.

Castor Mite (Tetranychus telarius, L).—Colonies of this reddish mites occur on the lower side of the leaves under a faint webbing and lacerate the surface. The attacked portions are deprived of the chlorophyll and turn pale white in colour. The grubs and adults of the Coccinellid—*Scymnus gracilis*, M—feed voraciously on these mites and keep them under check in nature. Recently the application of DDT for some other pests was found to bring about in its wake an inordinate infestation of these minute organisms, the probable reason being that the chemical has high lethal effects on the parasites and predators which keep these mites in check, while it has little or no action against the pest itself.

Alternative hosts.—A variety of host plants are subjected to the infestation by this mite. They consist of Ganja (*Cannabis sativa*), Tomato (*Lycopersicum esculentum*), Cambodia cotton (*Gossiypium hirsutum*), Rose (*Rosa* spp.) and Jasmine (*Jasminum sambac*), Agathi (*Sesbania grandiflora*), *Clitoria ternata*, *Aristolochia bracteata*, *Alysicarpus longifolius*, *Argemone mexicanum*, *Solanum nigrum*, *Morus alba* (mulberry), *Sesbania aculata* (Daincha). *Codiocum interruptum*, *Acalypha wilkiesiane.*

Control.—Dusting flowers of sulphur or spraying with lime sulphur is the approved remedy. A good wash with the extract of the kernels of *Thevetia nerifolia*, J. was also found to give equally good results

Plate 139.—*The betel vine bug*—Disphinctus politus, W. P. 991

Plate 140.—*The agathi weevil*—Alcides bubo, *F.* P. 992

10. Narcotics, Plantation Crops, Drugs, etc.

The Betelvine—(*a*) *The betelvine bug* (Disphinctus politus, *W*).—This bug is severe in parts of the Ceded Districts during the months of October-November. The reddish brown female thrusts her eggs inside the young and tender tissues. The nymphs and adults puncture the leaves and suck up the nutrition. The affected spots subsequently develop a blistered appearance and the quality of the leaf is spoilt. In Ceylon a number of plants such as *Cuphea jurullensis*, *Peperomia* sp., *Acalypha* sp., and Guava have been found to serve as alternative hosts. In Bellary district, young leaves of guava and mango were found punctured by the nymphs during rains but no adult bug was noted at any time. No natural enemies have been recorded so far. (Plate 139).

Control.—A number of methods like hand-netting, dusting Calcium cyanide, tobacco dust and Belumnite, spraying of tobacco decoction, and use of cone traps were tried from 1927 onwards but none of them proved to be either economical or efficient. Recently DDT and BHC, both in the form of spray and dust, were found to cause a complete extermination of the pest and between the two, BHC spray 0·05 per cent had a quicker knock-down effect, but the advantage with DDT is that it does not affect the quality of the leaf.

(*b*) *The agathi weevil* (Alcides bubo, F).—Agathi (*Sesbania grandiflora*) is a common vegetable and fodder crop but is more extensively grown as a standard for betelvine plantations. One of the important pests against which this plant has to contend with is this weevil. (Plate 140).

The adult is a fairly big sized insect, red in colour with white striations and a prominent beak. Eggs are thrust inside the plant tissue and the grubs on hatching, feed on the internal matter. Characteristic swellings develop as a result of the internal irritation and young plantations are often completely ruined. The weevils live for a fairly long period and one individual has been found capable of laying 85 eggs in the course of 42 days.

The two important alternative host plants for this weevil are cluster beans and indigo. The only natural enemy recorded to attack the grubs is a Braconid—*Compyloneurus ceylonicus*, C.

Control.—Clipping the attacked shoots with the grubs inside and collection of beetles were some of the methods advocated so far. Arsenical poisons have also been tried with indifferent results. The weevil was very severe in some of the gardens round about Coimbatore during 1948–49 and advantage of this opportunity was taken to conduct a few trials with BHC and DDT both as dusts and sprays in different combinations. Both the chemicals were found to cause a high mortality, but BHC spray at 0·1 per cent effected a quicker and a more thorough extermination.

One of the minor pests which regularly infests these plants in the lablab-bug—*Coptosoma cribraria*, F. BHC D 025 was equally effective against this also.

Pests of tobacco—(*a*) *The tobacco caterpillar* (*Prodenia litura*, F).—This is a serious pest with polyphagous habits. Besides tobacco it feeds on a number of crops like castor, banana, agathi, tomato, cabbage and ganja. Irreparable damage is often caused to tobacco nurseries and sometimes, to the transplanted crops also.

Eggs are laid on tender leaves in masses covered with brown hairs. Small darkish caterpillars hatch out in four or five days and feed gregariously during the earlier stages but get distributed as they grow in size. The full grown larva is about 1½ inch in length, pale greenish in colour with dark markings. Considerable variations are also met with in the body colouration. The worms are nocturnal in their habits, feeding during nights and hiding under the clods during day time. Pupation takes place inside the soil. The adult, a dark brown moth, emerges in about a fortnight.

Two Braconids—*Apanteles prodeniae*, Vier. and *Chelonella* sp—and an Ichneumonid—*Dioctes argenteopilosa*, C. are commonly found to parasitise the larva. The Pentatomid bug *Canthecona furcellata*, W. has also been found to decimate the caterpillars in their thousands.

Control measures.—The pest can be controlled by the collection and destruction of egg masses and by clipping off the leaves along with the groups of young caterpillars. Flooding may be tried. Digging trenches may prevent the migration of the caterpillars from one field to another. Stomach poisons may be tried in the case of valuable nurseries. Recent trials have shown that BHC 5 per cent dust effectively controls this pest, but the after effects of the application of the chemical on tobacco have yet to be investigated.

(*b*) *The ragi leaf noctuid* (*Laphygma exigua*, Hb.).—This is one of the cutworms which often devours entire plots of ragi and tobacco nurseries. Eggs are laid in groups on the lower portions of the plant and the caterpillars, on hatching, feed voraciously on the foliage. Pupation takes place under the soil. The incidence of the pest has been observed in varying degrees of intensity on onions, chillies, lucerne, indigo, gingelly, cowpea, brinjal, radish, amaranthus, daincha, turmeric, mango, castor, ganja, coriander, sorghum, agathi, cotton, etc. A sand dune weed—*Gisekia pharnaceoides*, L. is reported to serve as a source of primary infestation in Guntur district.

Natural enemies—*Sturmia inconspicuoides*, B and *Actia monticola*, M. are the two dipterous larval parasites, while the chalcid—*Trichogramma minutum*, R. parasitises the egg-masses. The Reduvid bug—*Rhinocoris fuscipes*—has been found to feed on the caterpillars.

Control.—The pest is usually controlled either by mechanical or by insecticidal methods. But a novel expedient was tried against the caterpillars on tobacco nurseries at the Imperial Tobacco Company, Chirala. Arsenical sprays were out of question since there was a likelihood of the poison being washed away

To face page 4.

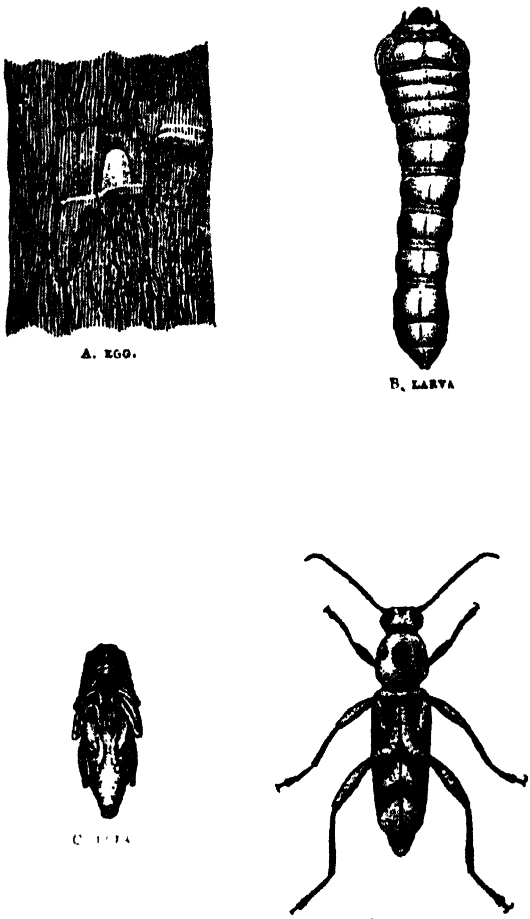


Plate 141.—*The Coffee borer*—Xylotrechus quadripes, *Ch.*

by the frequent overhead splashes of watering. The pest being particularly partial to ragi, successive rows of this millet were raised as a trap crop right round the nurseries. These were naturally preferred for oviposition by the moths. Removal and destruction of the egg masses and caterpillars along with the plants (ragi) was but an easy affair. Recently both BHC and DDT dusts at 5 per cent have been found quite effective.

(c) *The tobacco root bug* (Stibaropus tabulatus, S).—These are Pentatomids having the unusual habit of attaching themselves in small numbers to the roots of the tobacco plant. Such plants turn yellow and look sickly and stunted in growth. The bugs are small, oval, deep brown insects, resembling cockchafer beetles. They burrow into and excavate passages and deposit their eggs singly near the roots or rootlets at a depth varying from three to six inches. The eggs are peculiar in that they are not of the usual Pentatomid type but are cylindrical with smooth round ends. Nymphs, whitish in colour and with a brown head, hatch out in about four to five days and attach themselves to the roots. No alternative host plants or natural enemies have so far been recorded.

Control.—Mixing crude oil emulsion or fish oil rosin soap with irrigation water has been suggested but the results are not convincing.

Pests of coffee—*The white borer* (Xylotrechus quadripes, Ch.) is one of the most serious pests of coffee in South India. (Plate 141.) The characteristic symptoms of damage are the formation of the small ridges on the bark and the snapping of the plant itself at the seat of injury. The adult is a dark cerambycid beetle with white bands on the wings. They emerge during April-May and October-December and lay eggs in the crevices of barks. The grubs remain superficially inside the bark during the first two months and then penetrate into the deeper regions. A fully developed grub is pale yellow in colour, about three-fourths of an inch in length with a broad head and a tapering body. They pupate near the surface of the stem and the entire life-cycle takes from six to twelve months. A Eupelmid *Metapelma*, sp. is found to parasitise the grub.

Control.—As this is a borer, the only possible method of control is a systematic uprooting and burning of the infested stems with a view to check the further spread of the pest. The Pest Act is in force in Madurai district from 1945 onwards, the object being to enforce the prompt removal and destruction of the infested plants. Recent trials like application of stem washes, smears, dusting DDT and BHC have been reported to give encouraging results.

Pests of pepper—*The pollu beetle* (Longitarsus nigripennis, M).—This is a specific pest of this important commercial crop and has been under investigation from the very early days. The adult is a small beetle with shining bluish wings and yellow head. The hind legs are stout and adapted for jumping long distances. The

eggs are laid inside small cavities made on the rind of the berry. Pale yellowish grubs hatch out in about ten days and bore through the ripening berries and feed on the seeds inside. Each grub is capable of damaging two or three berries. They feed actively for about one month, and then drop down to the soil and pupate in a chamber of soft earth. The adults emerge in about a week. The damage is often reported to be serious.

Control.—The control of this insect has been a problem. Hoeing the soil was advocated to kill the pupae. Spraying with the deterrents like Bordeaux mixture gave encouraging results but the treatment was later followed by an inordinate infestation by mealy bugs—*Pseudococcus virgatus*, C *and Pinnaspis aspidistrae*, S. The probable explanation is that the fungicidal wash has had lethal action against the parasitic fungi which may be exerting a natural check on the mealy bug.

The pepper scale (Lepidosaphes piperis, G).—This is a small grey, boat-shaped scale found in millions on the underside of the leaves as well as the vines. Badly infested vines gradually dry up.

Pruning and burning the infested portions may help to keep the pest in check. Contact sprays have not so far given any convincing results.

Pests of cardamom—*The cardamom thrips* (Taeniothrips cardamomi, R).—Reports about the serious damage caused by these minute insects in the Anamalais were recorded from 1935 onwards and the incidence increased in its intensity during recent years. Preliminary investigations were, therefore, taken up, but no headway could be made due to the highly complicated nature of the problem. A comprehensive scheme of research, partly financed by the Imperial Council of Agricultural Research was sanctioned in the year 1944 and work commenced at Valparai on the Anamalais and the venue of work was later shifted to Singampatti in the Tirunelveli district in 1946. Definite methods of control having been evolved, it was considered that the continuation of entomological aspect of the scheme was not necessary beyond November 1949. The scheme was right through under the administrative control of the Government Mycologist, Coimbatore, the Entomologist giving the necessary technical advice.

The adults are minute, dark-brownish slender-bodied insects and possess two pairs of fringed wings. The flower heads and leaf sheaths teem with hundreds of the thrips in all its stages. They lacerate the tissues and feed on the cell sap causing a heavy shedding of the flowers. In the case of those which survive and develop into fruits, the pods are undersized, malformed and shrunken and show the characteristic scab injuries. The seeds show very poor development and lack in the fine aroma of the healthy pods. The scabbed fruits obviously command a poor price in the market and the approximate loss caused by the shedding of the flowers and scabbing is estimated to be anything between

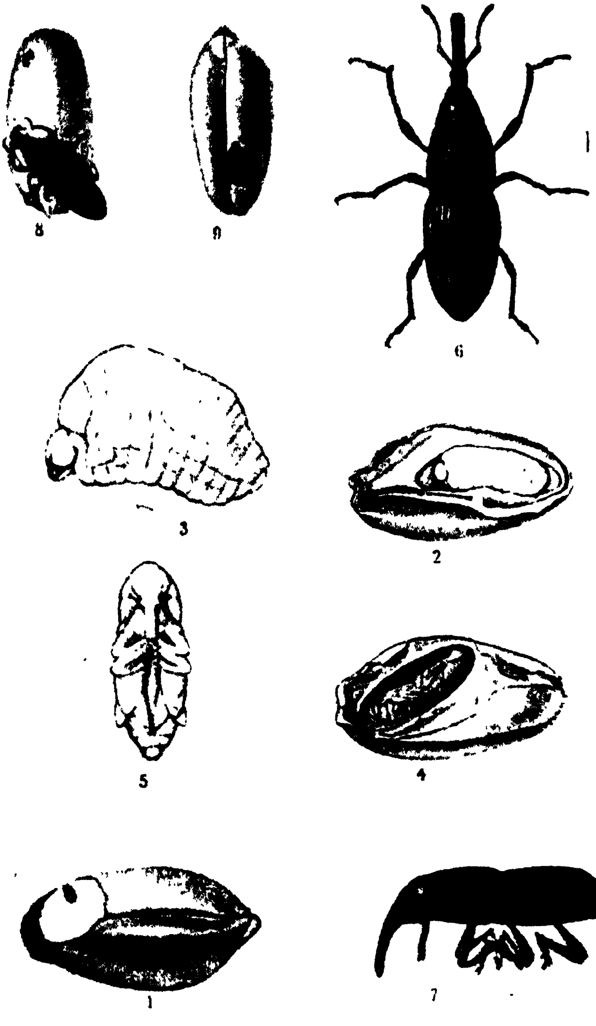


Plate 142.—*The rice weevil*—Sitophilus (Calandra) Oryzœ, *L.* P. 999

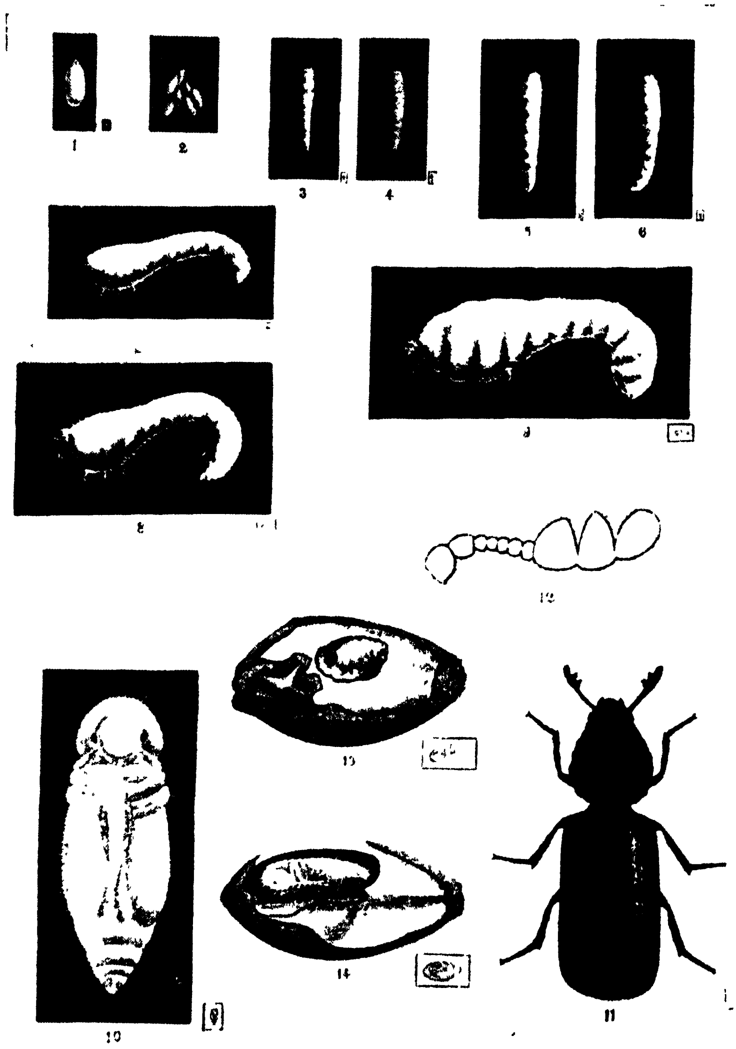


Plate 143.—*The paddy borer beetle*—Rhizopertha dominica, *F*. P· 1000

50 and 75 per cent. The redeeming feature, however, is that the fruits are susceptible to the damage only up to the stage when they are about 6 mm.

The following plants have been noted as alternative hosts of this pest: *Amomum cannaecarpum*, A. *involucratum*, A. sp., *Hedychium flavescens*, H. *venustum*, *Remustia*, *anephora*, *Colocasia antiquorum*, *Alocasia* sp., wild plantain (*Musa*, sp.)., etc.

No natural enemy has been recorded on this insect.

Control measures.—A variety of insecticides such as Paris Green, Tartar Emetic, DDT both as dust and spray in various formulations, tobacco dust and decoction, Acorus, Lobelia, Dede Tane, Sandotox, Nicotox, Nicophytan, Deriphytan, BHC, Nicotine sulphate, etc., have been tried against the pest. It has now been definitely established that BHC 5 per cent dust applied once a month at the rate of five to six pounds per acre or Nicotine sulphate spray 0·05 per cent at 25 gallons per acre gives the maximum control.

Application of the chemical to the panicles alone, has the desired effects at minimum expense and trouble.

11. Stored Products.

Deterioration of foodgrains in storage is partly brought about by a superfluous moisture content of the grains, which favours the development of certain bacteria and moulds. The moisture in the grains should not exceed 14 per cent and this can be achieved by adequate drying of the grains and stacking the bags under dry conditions with enough dunnage.

The next important aspect in the conservation of grains is the prevention of damage by insects, which often take a heavy toll of the material, produced and stocked at considerable expense and trouble. A number of insects are concerned with the problem and a short account of them is furnished below:—

The rice weevil (Sitophilus oryzae, L).—This is commonly found infesting grains like rice, sorghum, maize, wheat, etc. It is reddish brown in colour and about ⅛ inch in length with a curved beak. Eggs are laid in small cavities scooped on the grain surface and the grubs, on hatching, burrow into the grain and emerge out only after reaching the adult stage. The total life-cycle is about one and a half months. The insects generally appear in swarms and the patches of powdery material, commonly thrown out on the external surface of the bag containing the grains is a diagnostic symptom of damage by this weevil. (Plate 142.)

The only natural enemy attacking this weevil is a Hymenopteous parasite—*Peiromalus oryzae*, C. found distributed all over South India.

The Rice borer beetle (Rhizopertha dominica, F.)—This attacks all grains. The adults are dark brown in colour with a hood like prothorax. The female lays her eggs on the surface of the grains. The grubs, on hatching, first feed on the grain debris,

bore into the seeds later and live inside till they pupate and reach the adult stage. The characteristic symptom of attack by this species is the presence of the circular patches of powdery material on the bags with a pin spot in the middle. (Plate 143.)

The red grain beetle (Tribolium castaneum, H.).—These beetles breed on broken grains, debris and flour and do not as a rule attack the entire grains. They are found in association with the other two species, probably feeding on their reject. The life-cycle takes about a month and a half. It generally imparts a particularly unpleasant smell to the material it infests. The external indication of damage by this beetle is the continuous ejection of floury stuff from the bags.

Pulse beetles Bruchus sp).—These are specific pests of pulses and grams. The beetle is brown in colour and heart-shaped. The infestation commences in the field itself and the insects are inadvertantly transported to the godown along with the produce, where they continue their damage. (Plate 144.)

The Rice moth (Corcyra cephalonica, H.).—Grains and flour are damaged by the caterpillars of this moth which lays its eggs directly on the material or on the bags. The caterpillars web the grains together, feed inside, pupating in silken cocoons. The life-cycle is completed in about 45 days. The webbing is a chief symptom of the infestation and the cocoons usually stick out on the seams of the bags. (Plate 145.)

Two parasites, a small Braconid—*Microbracon hebetor*, S—and a Chalcid—*Antrocephalus mahensis*, M—usually seen in large numbers in store houses and godowns exercise a considerable degree of control over the pest.

The fig moth (Ephestia cautella, W).—This is a pest of stored groundnut. The caterpillar is white with a pinkish tinge and spins long tubular galleries in the food material. The adult is greyish in colour with transverse stripes on the forewings. This caterpillar-pest also is kept in check in nature by a very efficient parasite—*Microbracon hebetor*, S.

The house rat (Rattus rattus rufescens, G).—The habits and depredations of this ubiquitous rodent are too well-known to deserve any special mention here. They are omnivorous and feed on anything which is consumable besides being the common carrier of the plague flea.

Control measures.—As these seldom excavate deep burrows, fumigation of the infested godowns with Calcium cyanide can be done whenever possible. Poison baiting with zinc phosphide has also been equally effective.

Control of insect pests of stored products.—The conservation of foodgrains has not been such a serious problem till recently, at any rate in South India, since large stocks of grains are not usually held in storage. Small quantities required for annual consumption in individual cases are usually stocked in underground pits, wooden

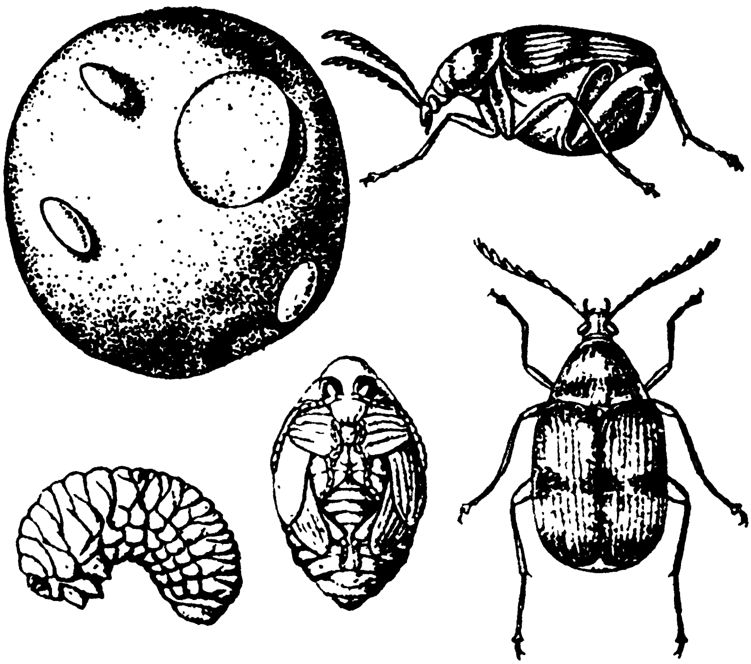


Fig. 1.—*Bruchus chinensis.* Attacked seed with three eggs and hole of emergence of beetle, larva, pupa, and dorsal and lateral views of beetle (magnified 12 times).

Plate 144.—*Pulse beetles.* P. 1003

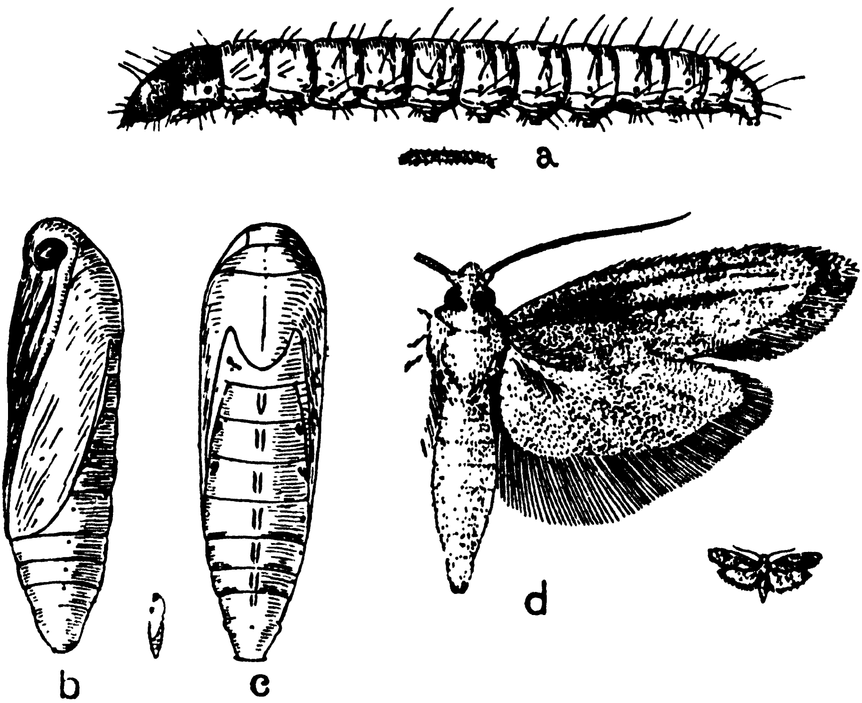


FIG. 343.—RICE MEAL WORM
(*Corcyra cephalonica*, H.)

Plate 145.—*The rice moth*—**Corcyra cephalonica**, *H.* P. 1004

constructions or insect-proof baskets, etc., which are all fairly efficient. Smaller stocks of seed material are looked after with particular care by occasional examination and sun-drying whenever necessary. Stray cases, where damage was reported, were promptly dealt with by simple methods like drying or small-scale fumigations with carbon-di-sulphite and a subsequent strict adherence to the accepted principles of godown sanitation.

The problem took altogether a different turn from 1943 when the Madras Government adopted a general policy of holding large stocks of grains, procured or imported, so as to ensure a regulated supply to the public. These stocks have inadvertently served as fertile breeding grounds for the myriads of the specific insect pests and consequently the storage of foodgrains suddenly became a problem of all-India importance. The situation became almost critical when about 6,000 tons of Australian wheat were landed at Madras during 1943 in a badly infested condition and the stocks were deteriorating rapidly. Ways and means had to be devised immediately to save the entire consignment from further deterioration. After due thought and care, fumigation with Calcium cyanide was decided upon. The untiring efforts of the Section in adopting the existing godowns to suit the needs, the fumigation of the stocks on a scale unprecedented for the whole of India, the subsequent measures taken to perfect the technique and the precautions adopted to prevent accidents would all go down in the history of grain preservation in India. The technique is since being adopted as a regular routine measure on a stupendous scale to conserve the enormous stocks held by the Civil Supplies Department by an elaborate staff of trained personal. The following is a short account of the procedure.

Entry of infested material from abroad is eliminated by a prompt examination of the arrivals at the ports and taking suitable measures on the spot. The godowns meant for stocking the food grains are first given a thorough cleaning and disinfestation with BHC D 024 so as to avoid any preliminary infestation. Insect-free bags are then stacked according to the standard specifications, giving proper dunnage below and providing enough alley-ways and gangways to facilitate proper aeration as well as frequent inspection. The stocks are kept under periodical scrutiny and if any infestation is feared, the external surface of the bags is promptly given a dusting of BHC D 024 (D 025 is now permitted to be used). If the situation gets out of control, fumigation with Calcium cyanide is resorted to as the last measure. For this, the building is first rendered air tight and the fumigant is pumped in at three to four pounds per 1,000 c.ft., through a number of apertures so as to ensure even distribution. The building is left closed for 24 hours during which period the fumigant kills anything living inside. The stocks are degassed after this period by keeping the doors and windows open until the last trace of the smell of HCN disappears. Samples of the grains are then drawn and sent to the Government

Analyst for test, and the stocks are released to the public only on his certificate regarding their fitness for consumption. Remnant stocks, if any, are again kept under observation and given an external dusting of BHC D 024 to prevent a reinfestation. While the above is the general policy, a system of priority of the issues is also being adopted. Stocks showing slight infestation are immediately released to avoid further damage and also to save the trouble and expense of fumigation. In some cases, a mere cleaning and reconditioning of the grains is also recommended.

Materials like rice, flour, oilseeds, etc., are not treated with either of these chemicals for fear of ruining their quality. Recent work has shown that even this difficulty can be got over, since harmless fumigants like Killoptera and dusts like Pyrethrum have come into vogue. All these methods are regularly in force and it is no exaggeration to state that this branch of Entomological service (Civil Supplies Department) has been mostly responsible for the availability of wholesome foodstuffs in this part of the country during all these years of stress and scarcity. In the following statement the quantities of grain handled by this branch during 1945 to 1948 are given :—

Place.	Recommended for priority.	Recommended for reconditioning.	Fumigated with Calcium cyanide.	Treated with BHC.	Treated with BHC. and priorities of release suggested.
	TONS.	TONS.	TONS.	TONS.	TONS.
Madras	46,000	909	12,649	8,936	65,105
Coimbatore ..	19,271	5,452	44,596	12,962	Nil.
Tiruchirappalli ..	16,502	9,492	335	17,016	Nil.
Vijayavada ..	19,528	5,920	2,697	1,996	Nil.
Total ..	101,301	21,773	20,277	40,910	65,105

The above figures do not include the quantities which were regularly examined in the godowns and also those which were examined at the ports of entry.

Insect pests of stored groundnut.—An intensive scheme of research for the study of these pests was in force during 1943–44 and the investigations were conducted at Coimbatore and Cuddalore. The more important species concerned are *Necrobia rufipes*, De G., *Ephestia cautella*, W., and *Dermestes cadaverinus*, F. with *Tribolium castaneum*, H. and *Corcyra cephalonica*, H. occurring in lesser numbers. Other pests of minor importance are *Carpophilus dimidiatus*, F., *Oryzaephilus surinamensis*, L., and *Loemophloeus* sp. The major pests were under detailed study and interesting information regarding their life-history, habits, nature and extent of damage and response to ecological factors was gathered.

A Braconid—*Microbracon hebetor*, Say. often parasitises caterpillars of Ephestia and Corcyra almost to the extent of exterminating them during certain years. A Chalcid and two species of Bethylids also were recovered from the infested material but their actual habits could not be investigated.

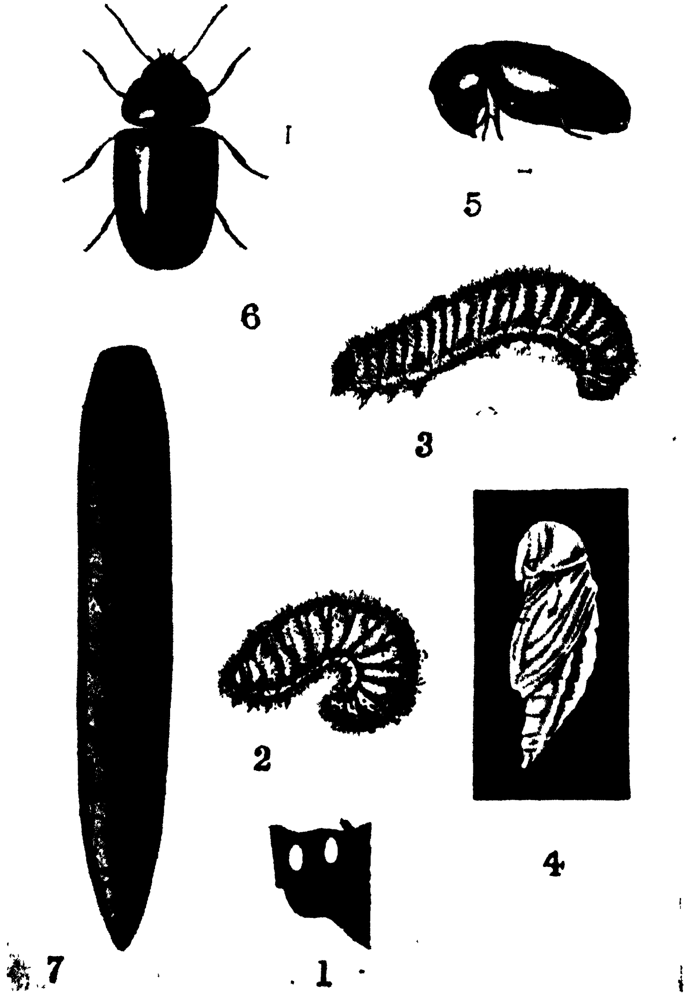


Plate 146.—*The cheroot beetle*—Lasioderma serricorne, *F*. P. 1008

Attempts to study the relative resistance of varieties like Coramandel, Khandesh and Pollachi-red did not give conclusive results.

Control.—Round about Cuddalore, it is a common practice to provide a permanent layer of sand with or without coir or gunny matting as a dunnage prior to stacking the bags. Kernels dropping out of the bags invariably get mixed up with debris and sand and provide more or less a permanent source of infestation. It was, therefore, considered that this practice should be either discouraged or that the sand should be periodically removed and a fresh layer applied. Provision of hard flooring would afford more ideal sanitary conditions. Periodical sun-drying of the kernels, though efficient, proved to be costly and at times impracticable. Cyanogas and Chlorosol were found to have a high lethal effect on the insects affecting the kernels. Laboratory trials were also conducted to study the effects of super-heating on the insect fauna. Adults of *Necrobia* sp. required an exposure of 15 minutes at 60° to 65° C while the larvae succumbed at 55° C. Adults and larvae of *Ephestia* died at a similar exposure at 45° C. The general indications of these studies are that all these pests are capable of infesting only decorticated kernels while the entire pods are seldom attacked. Reduction of the period between decortication and storage appears to be the most practicable method of control.

The groundnut pod bug (Aphanus sordidus, F).—This is another pest which occasionally takes a serious role in the godowns. The adult is an active blackish brown bug more commonly occurring in its hundreds at the harvest time and sucking the oily matter from the produce.

The Cheroot beetle (Lasioderma serricorne, F).—Reports regarding the damage done by these beetles to cured tobacco and cigars were received from leading firms in Madras in 1912. (Plate 146.)

The small red beetle lays her elongated white eggs on tobacco. They hatch after four days and the tiny white grubs eat their way inside. The larvae are responsible for the heavy damage. The full-grown grubs are stout and fleshy with fine brown hairs. They pupate within the food material encased in silken cocoons. The adults emerge in about a week and continue the damage. The life-cycle from egg to adult takes about a month. Ginger, turmeric, black pepper, chilli pods, etc., are some of the other materials affected by this beetle.

Fumigation with Chlorosol (Killoptera) at the rate of 20 lb. per 1,000 c.ft. for 24 hours has been found to give fairly good results. The advantage with the fumigant is that it is absolutely harmless and does not affect the flavour and quality of the fumigated material.

The Scolytid beetle (Cocotrypes dactyliperda, F).—A report was received from a local factory during 1947 to the effect that buttons manufactured out of dum nuts were being ruined by this

beetle. Any method suggested had necessarily to fit into the process of manufacture and render the finished product insect-proof at least for some time. Fresh buttons were boiled separately with DDT, BHC, Sodium arsenite 2 per cent and Mercuric chloride 0·5 per cent dried and kept under observation. They were not infested up to a period of three months. Dusting the cardboard containers with DDT and BHC 2 per cent had an equally good repellent effect.

12. Cattle and Household Pests.

Among insects belonging to this category, the housefly and other flies which are a source of nuisance to cattle as well as to human beings received some attention. The cattle at the Central Farm, Coimbatore, were subject to considerable annoyance by these flies periodically. Investigations were taken up during 1930–31. On a careful scrutiny, it was found that over a dozen species were concerned in the trouble, of which the domestic fly-*Musca nebulo*, Fb. formed the most prominent. Most of them breed in cattle manure and have a very short life-cycle, the egg period lasting from 8 to 24 hours, the larval stages for three days and the pupal one extending for about six days.

The problem was tackled from three different angles, viz., (i) use of repellents, (ii) control of the breeding ground, and (iii) trapping of adults. The repellents consisted of Creosol, neem oil, etc., but they proved to be of very little use, their action, at best, lasting only for a short time. Attempts at control at the breeding ground with insecticides were equally futile and the use of the maggot trap designed by the Section was more of academic interest than of any practical and immediate benefit. Another method, which was subsequently found to give appreciable relief was the covering of the manure with layers of tank silt at definite intervals. Access of the flies to the manure was thus minimised, the additional advantages being that the quality, as well as the quantity of the manure were improved. Formalin with milk, fly papers, and the ' Minnesota ' fly trap were all given a fair trial to trap the adults. Of these, the last mentioned contrivance, with rotten fish or meat as bait, attracted quite a large number of the flies. The results even in this case were not entirely satisfactory, since the catches represented but a poor percentage of the flies which were still at large.

Another instance of a major nuisance by cattle flies was from Sidhout in Cuddapah district during 1942. The species concerned was mostly *Stomoxys calcitrans*, L. These flies were settling on cattle in their hordes and apart from sucking their blood rendered them vicious and unruly by the tickling sensation caused. Investigations revealed that the flies were breeding in their millions in the groundnut cake which was being liberally applied to the melon crop for which the locality is famous. The only line of relief, which could be planned, was to discourage the

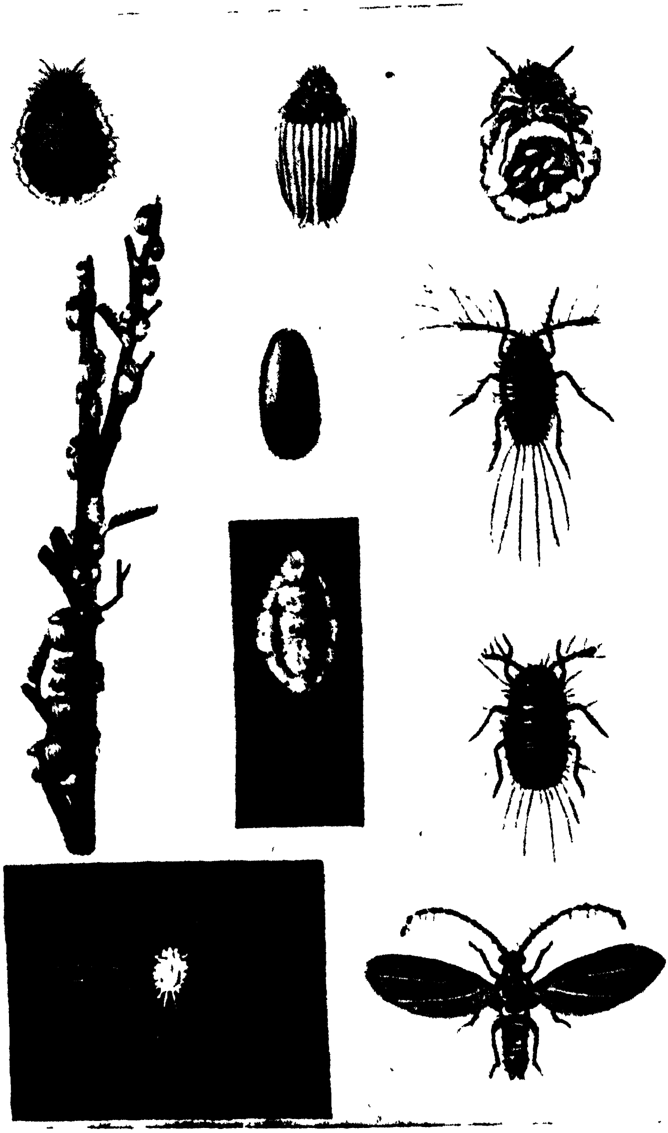


Plate 147.—*The fluted scale*—Icerya purchasi, *M.* P. 1012

use of this manure. The ryots were at first not forthcoming to co-operate with the department and a special Pest Act prohibiting the application of this cake was, therefore, enforced during 1943. As a result of the rigorous enforcement of the provisions of the Act, the problem is not so serious during recent years.

Subsequent work has revealed the enormous possibilities of controlling the adults by the use of BHC and DDT. Sprays of the chemicals, even at a low concentration of 0·05 per cent applied on their resting places, caused a wholesale decimation of the population and the residual effects were found to last from seven to ten days. The action of these chemicals against the maggots is still under investigation.

BIOLOGICAL METHOD OF CONTROL.

This line is one of the latest developments in the field of Economic Entomology and this novel method consists of controlling pests with the help of their own natural enemies. Its success is, however, subject to certain limitations such as availability of efficient parasites, their adaptability for laboratory rearing, their ability to thrive under field conditions, etc. The method is generally tried in cases where the pests concerned are either too widespread or too inaccessible for other methods of control. The Entomology Section has been interesting itself in this line for the past two decades and remarkable results have been achieved in a few cases. A short resume of the same is given below :—

(1) *The fluted scale* (Icerya purchasi, Mask).—This is a scale insect, which has earned great notoriety as a polyphagous pest on a variety of fruit trees in the Western countries. The bug is characterized by a prominent white egg-sac with a number of corrugations on the outer surface. Each egg-sac may contain hundreds of the brick-red eggs which hatch out into tiny red-coloured nymphs with prominently long dark legs. These crawl about in search of succulent portions of the plant and establish themselves there. They moult thrice in the course of their development and change their feeding spots after every moult, attaching themselves permanently after the last moult. The nymphal stage extends from 2½ to 4½ months according to the weather factors. (Plate 147.)

The pest had somehow got an entry into this State and was found to have spread to an alarming degree on a variety of wild vegetation on the Nilgiris by about 1928. The scale had a formidable list of over 100 host plants but fortunately the only crop of economic importance which had suffered most was the wattle—*Acacia decurrens*. As the potentialities of this scale were immense, immediate steps were taken to bring it under control. The only recognised method is to seek the help of its specific

exotic predatory beetle—*Rodolia cardinalis* Muls. The beetle and its grubs feed exclusively and voraciously on the adults and nymphs of *Icerya* and are capable of practically exterminating the pest. Entomologists abroad were immediately contacted for a supply of the beetles and pending their arrival, tentative measures like cutting and burning of the vast areas of wild vegetation infested by the scale were carried on. The consignment of the beetles was at last received from California in May 1929. The beetles were immediately taken to the Nilgiris and accelerated breeding and liberation were commenced forthwith in a special laboratory opened there. Another consignment was received later from Egypt in 1930. The work progressed quite satisfactorily and the incidence of the scale was practically reduced to negligible limits by 1931. A severe outbreak on *Acacias* was again reported, this time from Kodaikanal in 1942 and an assistant was immediately deputed to the locality to take up the breeding and liberation of the predator beetle. It subsequently transpired that the scale had broken out again in a virulent form on the Nilgiris as well. Intensive work was taken up in May 1943, under a special unit of staff with a gazetted officer stationed at Fernhill on the Nilgiris. The work at Kodaikanal was also in his charge. The work was continued under the ægis of the Madras Government till November 1945. As the problem was later considered to be one of all-India importance, the activity was later merged in a special scheme under the joint auspices of the Madras Government and the Government of India, which continues to function as such. As a result of the concentrated liberation of the beetles, the infestation by the scale has been brought down to the minimum and the releases are being continued more to prevent the recrudescence of the pest, especially in view of the fact that the Forest department have now taken up the extensive cultivation of *A. decurrens* for its valuable tannin contents. Attempts to introduce an exotic fly parasite—*Cryptochætum iceryæ* Will. were not successful.

The indigenous natural enemies observed on the hills comprise of the lady bird beetles, *Rodolia roseipennis* Muls. and *Scymnus* sp., the caterpillar *Stathmopoda melanochra* M., a species of mite and a fungus disease *Cladosporium*.

Apart from the large-scale multiplication and release of the beetles, attempts to improve the technique of rearing are also in progress. The localities are being regularly surveyed for the spread of the scale and prompt measures taken. An eye is always kept on the activities of indigenous natural enemies and alternative host plants, etc.

(2) *The black-headed caterpillar* (Nephantis serinopa).—Vide pests of coconut.

(3) *Early borer of sugarcane* (Argyria sticticraspis).—Vide pests of sugarcane.

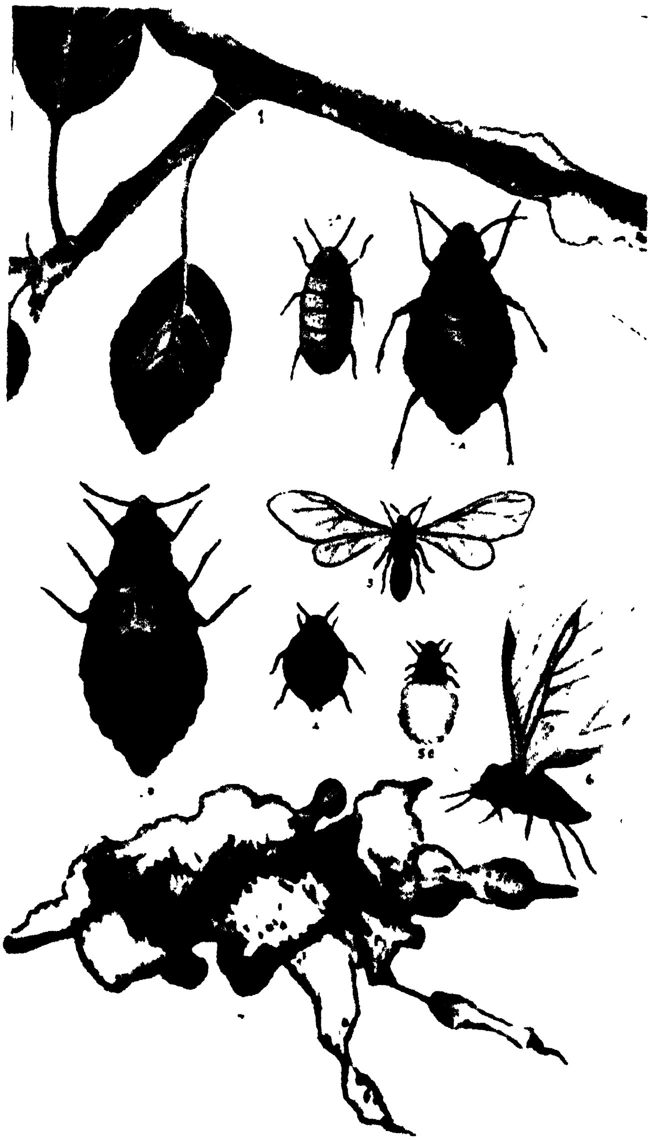


Plate 148 —*The apple woolly aphis*—Eriosoma lanigera, *H*. P 1015

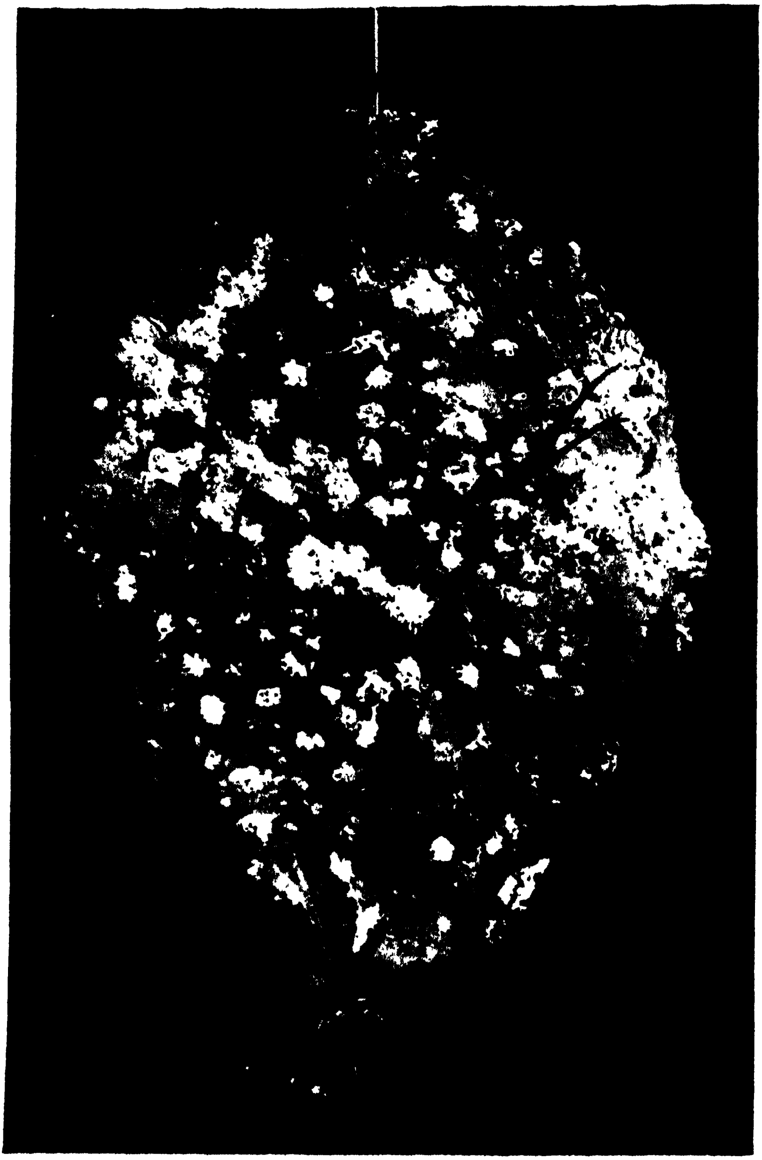


Plate 149.—The prickly pear cochineal—Dactylopius tomentosus, *L.P.* 1016

Plate 150.—Thevetia neriifolia. *Flowers and fruits.* P. 1018

(4) *The apple wooly aphis* (Eriosoma lanigera, *H*).—This is a serious pest of apples. (Plate 148.) Colonies of these aphids with their characteristic snow-white woolly covering get established on the branches as well as in the roots of the apple tree and cannot be satisfactorily controlled by the contact insecticides in vogue. The recognised method of control is by a systematic colonization of its specific parasite *Aphelinus mali* Hal. Consignments of these parasites were obtained from the Punjab by about 1940 and liberated in the Pomological station, Coonoor. The work was intensified from 1944 onwards and appreciable control has been effected. The introduction of the resistant varieties in apples also has been quite successful.

(5) *The cotton bollworn* (Platyedra gossypiella, S).—The egg parasite *Trichogramma* was tried against these worms also. Weekly releases at 10,000 per acre, commencing from the flowering season, were continued till the ripening of the bolls. Fortnightly counts of the incidence showed a progressive decline in the infestation. The yield did not increase appreciably, but the quality of the lint was better in the treated plots.

Attempts were also made to control the castor semi-looper (*Achœa janala* L.), the paddy stem-borer (*Schœnobius incertellus W*) and the brinjal *Epilachna* with their respective parasites, but the results have not been very convincing.

Weed control—The prickly pear (Opuntia dillenii).—Everyone in South India is familiar with the common hedge plant, the prickly pear. This bush, though it is a cheap and effective fence, had subsequently spread almost all over the waste lands round about villages and towns and rendered them unfit for any useful purpose, apart from harbouring poisonous reptiles and sometimes even wild animals like pigs. Mechanical and chemical methods of destruction are practically useless against this obnoxious weed.

A small coccid, the *Cochineal* insect (*Dactylopius tomentosas* L) is a specific pest on this prickly pear and is capable of practically exterminating it within a short time. (Plate 149.) This bug is a minute insect, purple in colour with a white waxy covering. The bugs and their young suck up the nutrition and the entire clump dries up on this account within a very short period. The scale was first introduced in Tirunelveli district during 1926 and in a short period exterminated the thorny cactus in the surrounding areas. The news about the beneficial activities of this cochineal very soon spread all over the country and the department rendered valuable service in despatching consignments of this insect to different parts of the country with the result that this troublesome cactus which has been such a nuisance so far has now become practically extinct.

Indigenous Insecticides.

The outbreak of the last war and consequent non-availability of insecticides from abroad naturally taxed the ingenuity of the Entomologist to try and see whether any of the indigenous material, especially plants belonging to the poisonous group, could be utilized in place of the imported chemicals. This category indeed afforded a valuable field of research and in the course of the experiments with scores of plants reputed to have toxic properties, the potentialities of a few came to light, some of them being recorded for the first time. Of these, the discovery of the insecticidal value of *Thevetia neriifolia*, J., ranks first.

Thevetia neriifolia, J.—(Plate 150). This plant is a native of South America and West Indies and has been introduced into India some years ago. Aqueous extracts prepared by soaking the mashed kernels in water for twenty-four hours were found to be highly toxic to most soft bodied insect forms. A strength of ¼ oz. of these kernels in one gallon of water with an equal quantity of soap is very effective against soft bodied insects like Aphids, Tingids, Psyllids, Thrips and leaf hoppers. Higher concentrations at half an ounce per gallon of water were required for leaf eating caterpillars like *Prodenia litura*, *Achæa janata*, *Papilio demoleus*, *Spodoptera mauritia*, *Laphygma exigua*, *Eupterote mollifera*, etc.

Another insecticidal plant to receive attention was *Acorus calamus* (*Araceæ*). (Plate 151). This is an indigenous semi-aquatic perennial plant common in the Western Ghats, Nilgiris, etc. The insecticidal properties of the rhizomes were first tried in the Section during 1938. The dust is highly useful for preserving seed-material free from insect damage. Two pounds of the dust mixed with 100 lb. of seeds gives adequate immunity for a year against the specific pests. The infusion prepared by soaking the powder at ¼ to ½ oz. per gallon of water, with an equal quantity of soap effectively controls aphids and leaf-eating caterpillars.

Yet another plant found to have insecticidal properties is *Lobelia excelsa* (*Companulaceæ*). (Plate 152). It grows wild on the Western Ghats, Nilgiris, Pulneys, Travancore, etc., at an elevation of about 6,000 feet. The leaves are first cured in shade and then chopped. Half a pound of the leaves are then soaked in a small quantity of water for about 12 hours. The infusion is filtered and the filtrate made up to one gallon and ½ oz. of soap is added to the fluid. The spray was found effective against aphids on snakegourd and cowpea, tingids on brinjal and mites on castor and bhendi.

The lethal properties of other well known insecticidal plants like Pyrethrum, Derris, Tobacco, *Tephrosia vogelli*, etc., were also fully tested. The contact action of the indigenous vegetable

Plate 151.—*Acorus calamus*. P 1021

Plate 152.—*Lobelia excelsa.* P. 1022

oils like those of gingelly, coconut, castor and groundnut was another aspect of study. Emulsions of these oils at the rate of ½ to one ounce in a gallon of water with a little soap were effective in controlling a variety of insects, ranging from aphids to big sized caterpillars like *Eupterote mollifera.*

SYSTEMATICS.

The importance of this fundamental aspect in the study of insects was realized from the very inception of the Section and the building up of a comprehensive reference collection was contemplated even as early as 1910. Extensive field collections of insects were made from different parts of South India, studied, identified wherever possible and incorporated in the laboratory collections. Specimens of doubtful identity were sent to Specialists abroad or to the British Museum for determination. With the steady accumulation of knowledge, specialised work on various groups was later possible in the Coimbatore Institute itself.

Substantial work has been done on *Braconidæ Thysanoptera, Coccidae, Curculionidae, Cecidomyidae, Acarina,* etc., and literature on numerous species new to science have been contributed by the section off and on. The invaluable reference collection of identified insects, which the Department can well boast of at the present day, is the result of concentrated work done during the past four decades. Even though the onset of the World War II brought about a slackening in this aspect due to pressure of economic work, interest in the line is being revived.

Recently (1945) the Indian Council of Agricultural Research under their " Scheme for establishment of various schools of research " in different parts of India, sanctioned the appointment of two Research Fellows for the Madras State to work on Braconidæ and Thysanoptera for a period of two years each. The object of the scheme is to prepare comprehensive reviews of literature and help the State Entomologist in the special study of these groups. The work on Braconidæ was started in 1947 and completed in 1949. The scheme on Thysanoptera is under progress.

EEL WORMS.

Among animals other than insects capable of causing loss to cultivated crops, the group of Nematodes is of no mean importance. These worms attack the rootlets causing the characteristic nodules in which they breed. The infested plants entirely fade away. The most widely distributed form is the rootgall eel worm—*Heterodera marioni,* G. It has a formidable array of over 50 host plants, wild and cultivated. Of these, pepper, betelvine, brinjal, tomato, tobacco, tea, pulses of different kinds, turmeric, cucurbits,

groundnuts, cruciferous plants, chillies, green manure crops, cinchona, etc., come under the category of crops of economic importance.

Control.—The control is difficult since these worms remain in the soil even after harvest and are capable of reinfesting the next crop. Attempts to sterilize the soil with chemicals like Carbolic acid, kerosene, Cyanide compounds, Formalin, etc., indicated that the treatments afford a certain amount of relief. But the application of these can at no time lie within the economic limits of the South Indian ryot. Commonsense methods like proper crop rotation, disposal of crop residues, keeping the land fallow for a few seasons may be followed with advantage. Breeding Nematode-resistant strains as well as the biological control with another species of Nematode are reported to have been tried elsewhere as possible control measures.

PEST CONTROL METHODS.

One of the main activities of the section since its inception has been the study of the bionomics of insect pests and devising ways and means of controlling them. To start with, only mechanical methods, broadly based on the life history, habits and vulnerable stages, if any, of the insects concerned, were devised and popularized. The next phase was to adopt some of the stomach and contact insecticides which were coming into vogue in other countries. Along with these lines of research, the utility of the natural enemies of crop pests for biological control was also investigated and their help pressed into service wherever possible. Some work has also been done on indigenous vegetable poisons with a view to use these as substitutes for the imported chemicals. Legislative measures for the enforcement of some special control measures and for preventing the entry of injurious insects from foreign countries or the inadvertant spread of some of the pests within the country itself, etc., were introduced later wherever necessary. Plant protection by chemical methods received a further fillip on account of the recent availability of the two new chemicals DDT and BHC. These insecticides are so efficient that they have almost superseded all the other methods till now in vogue. A short account of the work done is furnished below.

The methods evolved can be broadly discussed as Preventive or Prophylactic and Curative or Direct.

Preventive measures.—These consist mostly of strict adherence to the general principles of plant sanitation, clean and good cultivation, adequate manuring, proper irrigation, etc. It is a matter of common knowledge that some serious pests like the Rice mealy bug, *Ripersia oryzae* Gr., the fruit moths, *Ophideres* pps. etc., breed on weeds and other rank vegetation and infest the

crops later. Elimination of such breeding grounds would, therefore, minimize the chances of infestation by such insects. Timely removal and destruction of crop residues as in the case of sugarcane, Sorghum, cotton, etc., is another simple method of preventing the undue multiplication of their specific insect pests. Besides these, good cultivation ensures a luxuriant growth of the crops which in its turn confers the necessary degree of vigour to withstand the ravages of insects. Breeding of pest-resistant strains, if successful, would by far be the most efficient and cheap method of plant protection. The evolution of the jassid-resistant strains of cotton and disease-resistant varieties of sugarcane represents some of the outstanding examples.

Direct methods.—These measures constitute a major line of attack, involving the use of mechanical devices, application of chemicals, utilizing other insect agencies like parasites and predators, etc., according to the circumstances.

(1) *Mechanical.*—The method adopted till recently against serious incidences of insects like the Rice grass hopper, the Rice bug, the Rice jassid, etc., was a systematic sweeping with hand-nets or bag nets. Minute organisms like Thrips and active insects like the betel-vine bug were controlled with the help of contrivances smeared with some sticky material. The strong attraction of certain insect forms to light was also taken advantage of in a few cases and setting up of light traps was one of the common remedies recommended against the Rice stem borer, (*Schœnobius incertellus*, W), the Rice jassid (*Nephotettix bipunctatus* Fg), the Kodu fly (*Pachydiplosis oryzae*, W), the groundnut surul puchi (*Stomopteryx nerteria*, M), etc. Digging out the burrows and catching field rats still forms one of the most effective and fool-proof methods of destroying these troublesome rodents. Some outstanding examples where such mechanical methods have been intelligently adapted for tackling insect pests in vulnerable stages of their life-history are the timely hand-picking of the adults of *Amsacta albistriga*, W., clipping of the wilted twigs against the orange borers, etc.

(2) *Chemical methods.*—Pest control with the help of insecticides is perhaps the most popular practice adopted all over the world. A certain amount of basic knowledge of the habits of the insects is, however, necessary for the judicious application of these chemicals. Leaf eating forms having biting mouth parts like caterpillars, grass-hoppers, beetles, grubs, etc., can be destroyed only with stomach poisons. These are generally arsenical compounds and are applied on the plants either in the form of a spray or dust at the prescribed dosages. The insects concerned while eating the leaves take in the poison also and die eventually. Among the stomach poisons formerly in vogue, were Paris green, Lead chromate, London purple, Zinc arsenate, etc., but these have recently been supplanted by arsenates of Lead and Calcium.

Insects like plant bugs, aphids, scale insects, etc., have the peculiar habit of piercing the plant tissue and sucking the sap and these require quite a different mode of treatment. Soaps, Oil emulsions, lime and sulphur washes, etc., are used in such cases and the mortality is caused by the spray fluids blocking the spiracles or breathing pores and causing asphyxiation. Tobacco also has been a specific in such cases but the lethal effects are brought about by the paralysis of the nervous system. A later development in the line was the adaptation of vegetable poisons like Pyrethrum, Derris, etc., which also cause mortality by paralysing the nervous system and have the added advantage of being non-toxic to man and higher animals. Investigations at Coimbatore have also indicated the high potentialities of other vegetable drugs like *Thevetia neriifolia, Acorus calamus, Lobelia excelsa* as well as emulsions of indigenous oils like those of gingelly, groundnut, coconut, etc. The problem of plant protection has more recently been completely revolutionized by the advent of the two wonder insecticides DDT and BHC. These chemicals have proved themselves almost a panacea against most of the external feeders with certain limitations and are rapidly, becoming popular, both on account of their high potency, ready availability as well as extreme cheapness.

(*b*) *Fumigants.*—These chemicals are generally used inside airtight receptacles or specially improvised chambers against household pests and more often against those infesting stored products. They are either volatile or have the property of evolving poisonous fumes when brought in contact with the moisture of the air. The surcharged poisonous atmosphere causes an entire annihilation of all lower forms of life inside the fumigation chambers. Carbon-di-sulphide and Calcium cyanide are the fumigants in ordinary use, but their application is fraught with danger to human life, not to speak of the fire hazards and as such they can be handled only under expert supervision. Naphthalene, Sulphur, Ethyl acetate, Carbon tetrachloride, etc., are some of the other fumigants recommended. Cholorosol or Killoptera (a mixture of Ethylene dichloride and Carbon tetrachloride) is of late gaining rapid popularity on account of its non-inflamable nature and better penetrating qualities. Smoke pellets of BHC and DDT are also coming into the market recently. The smoke from these pellets, when they are burnt inside enclosed spaces, has a high disinfecting effect.

(*c*) *Rodenticides.*—One of the most serious non-insect pests the ryot has to contend with, both in the field as well as in the godown, is the ubiquitous rat. A number of chemicals reputed to have lethal effects like Barium carbonate, Plaster of paris, Strychnine, 'Antu', Zinc phosphide, etc., were given a fair trial. Of these, only the last-mentioned chemical, when exposed mixed with a suitable vehicle, gave considerable relief.

(*d*) *Repellents.*—These chemicals when applied on plants have the inherent property of rendering them unpalatable to their insect foes. Bordeaux mixture, dry slaked lime, calcium carbide residue, tobacco dust, etc., are some of the common substances having this reaction.

Precautions to be taken in the use of insecticides.—The information on insecticides will not be complete without a word of caution on their use before advocating them to the lay man. As a general principle, it should be remembered that anything which is capable of killing insects and other lower organisms is also likely to injure higher animals as well, when taken in larger doses and neither DDT nor BHC and, as a matter of fact, none of the arsenical preparations are exceptions to this rule. These insecticides should, therefore, be applied with a certain amount of care, especially on vegetables which are likely to be harvested and consumed immediately. It would be safer to stop treating such crops at least two to three weeks before harvest and even then the harvested material should be thoroughly washed before use. BHC and DDT have probably to be handled with greater care as they have come into the field only recently and as there are still some highly controversial issues regarding their toxicity to man and other higher animals. The scientific as well as public interest in this aspect has probably been whetted by the very high insecticidal potentialities of these chemicals and their consequent unprecedented popularity at present. A gist of the precautions as advocated by the firms dealing in these insecticides is furnished for information to interested parties.

(1) Vegetables treated with BHC products may have a slightly bitter taste. This, however, disappears after a few days and can be avoided if the chemical is not applied within two to three weeks before harvesting.

(2) In the case of potatoes and cucumbers BHC D 025 should not be dusted at a dosage higher than 40 lb. per acre. Results of BHC treatment on root crops have been variable and BHC has been found to taint carrots, beetroots and onions under certain conditions.

(3) Plants of the cucurbitaceous family are sensitive to DDT and BHC when they are applied especially in the form of oil emulsions and with the present knowledge on hand, it is better not to use these chemicals on these plants.

(4) Oil. emulsions of both BHC and DDT should not be allowed to be in contact with the skin for long periods, as they are likely to be absorbed.

(5) Oils generally used for emulsifying these chemicals are often inflammable and due precautions are, therefore, necessary.

(6) The residual action has been found to be more in the case of DDT and it is advisable not to use fruits and vegetables treated with this chemical, without peeling the outer skin.

(7) Both DDT and BHC have a fatal effect on honey bees if they visit plants treated with them. This fact has to be borne in mind while dealing with areas situated near large apiaries.

A few broad conclusions derived from the experiments conducted with these chemicals at Coimbatore, may not be out of place here.

Both BHC and DDT have definitely shown a certain amount of selective action against different categories of insects and as such, they should not be used indiscriminately.

BHC, either as dust or spray, causes a high percentage of mortality against a wide range of insects from big sized grasshoppers to minute forms like thrips, Aphids, etc., but the concentration has to be varied according to the insects concerned. Its knock-down effects are quicker but the residual effects shorter. It appears to exert but a feeble action against jassids. DDT, on the other hand, is almost a specific against jassids and has also a longer residual action. It has not been convincing so far against other forms of insects and is practically inert against mites. Despite the selective action, there are also a few instances where both the chemicals are equally efficient.

(e) *Appliances.*—Insecticides are used either in the form of a fine spray or as a thin cloud of dust. The fluid forms are applied with sprayers and the dusts with dusters. A variety of patterns of these appliances are available in the market ranging from hand syringes and dusters for small-scale use to power-driven machines for treating bigger areas. It may also be of some interest to mention here that aeroplanes and helicopters are in regular use for dusting more extensive areas in the Western countries.

(f) *Biological control.*—This method consists of the utilization of the specific natural enemies of certain pests and is generally practised in cases where the latter are either too wide-spread or inaccessible to other methods of control. Instances of outstanding success achieved in this line are the control of *Icerya purchasi* Mask. by the lady bird beetle—*Rodolia cardinalis*, Muls., of *Nephantis serinopa* M. by its hymenopterous parasites, and of the obnoxious prickly pear by the Coccid—*Dactylopius tomentosus*, L.

(g) *Legislative methods.*—The provisions of law enacted by the legislatures are sometimes resorted to to enforce certain control measures for the prevention of the spread and multiplication of indigenous pests and also the entry of foreign ones. These measures are dealt with in more detail elsewhere.

Details of all these methods have been elaborated in the body of the memoir in appropriate places under the respective pests.

THE PESTS AND DISEASES ACT.

Legislative measures for pest control are usually resorted to under emergent situations when serious damage by insect pests is imminent. Such situations arise when pests break out in a virulent form over wide areas and where there is a lack of co-operative effort on the part of the ryots to adopt the control measures suggested by the Department. Another instance is the possibility of the inadvertant entry of some of the highly injurious foreign insects along with the indiscriminate importation of seed and plant material from other countries. Thirdly there have also been one or two occasions where it was found necessary to localise some of the insect outbreaks where they had already occurred and check their spread to other parts of the country. Experience has shown that attempts to popularise such measures by persuasion and advice do not always have the desired effects. The acid of legislation is invoked only in such extreme and emergent cases. Madras is, perhaps, the first State in India where the control of insect pests was sought to be effected with the aid of legislative measures. The Madras Agricultural Pests and Diseases Act, 1919, received the assent of the Government to include any pest, plant disease or noxious weed in a notified area as dangerous to health or injurious to crops, etc., and to take such measures as are deemed necessary for their effective control.

A short resumè of the various insect pests against which the Act has been enforced in the State is given below :—

Boll-worms and the stem weevil on Cambodia cotton (Platyedra gossypiella S., Earis fabia, E., insulana and Pempherulus affinis, *F*).—Cambodia cotton was introduced in this State about four decades ago and is now grown extensively as a garden as well as a dry crop. The hardy nature of this variety, its higher yielding capacity and the attractive prices offered for its longer stapled lint along with the readiness with which the crop has adapted itself to South Indian conditions were all factors favourable for its immediate adoption. This exotic variety became popular very soon and its cultivation has now fitted itself into the regular agricultural practices in the districts of Coimbatore, Salem, Tiruchirappalli, Ramanathapuram, etc. The extensive cultivation of this crop had brought, in its wake, the heavy incidence of some of its serious insect enemies like the boll-worms, the stem weevil, etc., and alarming reports about the steady deterioration of the produce were received by 1918. The situation was so bad that it was feared the very prospects of this remunerative crop were at stake unless some drastic measures were immediately taken. A detailed study of the bionomics of these pests was instituted forthwith. It was found that they were widely distributed in a fairly serious form and one of the factors contributing to the unrestricted multiplication of the pests was the pernicious practice of keeping the

crop in the field for two or even three years in the dry land areas, the ryots being satisfied with what little they got from the struggling crop. Ordinary methods of pest control were not feasible because of the wide distribution of the pests as well as their internal feeding habits. The only advice that could be given under the circumstances was a complete eradication of the crop for a particular period so as to starve out the pests. The harvest of the kapas is generally completed by July-August and the next crop is sown by the first week of September. The most convenient period for effecting this " off season ", therefore, reduced itself to the one between final picking of the standing crop and the sowing of the succeeding one. It was accordingly decided that a close period from the 1st August to the 1st September would meet the needs and that it could be easily made to suit the agricultural practices of the respective tracts. As a large scale action especially over such extensive areas by mere persuasion could at no time be thought to be feasible, the Pest Act stipulating the complete removal of the crop by the 1st August and the sowing of the succeeding one only by 1st September was enforced for the first time during July 1919 in Coimbatore district. The Act was extended to Salem, Tiruchirappalli and Madurai districts during the next year. Its administration was in the hands of the Agricultural department with the active co-operation of the Revenue authorities as well. The notification relating to the enforcement of the legislative measures was first given wide publicity. The departmental officers visited the areas and explained to the ryots the advantage of the method suggested. Failure to pull out the plants by the stipulated date was declared an offence. The Revenue authorities were empowered to enforce the stipulations.

It was later found that the period of the sowing was not uniform all over these cotton growing areas mostly due to the vagaries of the monsoon and as such the later sown crops were invariably found in bolls and flowers at the time when they should be pulled out according to the conditions of the Act. As this entailed considerable loss to the ryots the date was postponed by a month with the result that the last date of the complete eradication had almost synchronized with the sowing of the next crop. The modified system continues as such in most of the notified areas of Coimbatore, Salem, Tiruchirappalli and Madurai districts. A few further modifications had also to be made in particular tracts in accordance with the peculiar local agricultural practices. For example, the monsoon is irregular and spread over a longer period in some of the villages of the Anamalai area and sowing season also has to be extended correspondingly. Under these circumstances the development of the later-sown crops is delayed. Further, the second flush (kar pickings) generally gives a good yield on account of the fertile nature of the soil and ryots are loath to lose this income. In such cases the last date for the removal of the crop has been fixed as 30th September and the Collector of the

district has been empowered to sanction a further extension of three weeks in genuine cases. A few other villages of the Coimbatore district exposed to the Palghat gap (e.g., Ettimadai, Pichanur, Tirumalaiyampalayam, Vallukuparai, etc.), receive heavy showers during July-August and as such the crops are sown earlier. The harvest is completed by June-July and the last date for uprooting has been fixed as 15th June for these areas with the date of sowing for the next crop as 1st August. An exception to the provisions of the Act has, however, been made for the " Masi pattam " of this variety which is in vogue in Ramnad district. The crop is sown by February-March and comes to the yielding stage by September. As the destruction of the crop at this stage would practically deprive the ryot of any yield these areas were exempted from the Act. More recently, this system of cultivation has spread to Madurai district (Thirumangalam taluk) and a similar exemption has been given to this tract also.

Results.—The Act has been in force for over 30 years but accurate statistics regarding the benefit or otherwise accrued by the legislative measures are not available. Mention has also to be made of a few inherent defects which nullify the effects of this legislative measure. The insects attacking Cambodia also breed on the indigenous cottons, as well as on a variety of alternative host plants, wild and cultivated. These are not included within the purview of the Act and a complete destruction of all these breeding material would well nigh be impracticable. Despite these facts, the general impression of the officers enforcing the Act, as well as that of the enlightened ryots, appears to be that the measure has done some good, since quality of the lint from these areas has, on the whole, been maintained at a better level. Apart from this, the imposition of the Act has also had a salutory effect in wiping out the undesirable practice of keeping the crop on the ground for indefinite periods in the dry lands.

In localities where good and intensive agricultural practices are in vogue, the cotton crop is invariably pulled out after the first picking by March, so as to make room for a food crop for which greater importance is attached, especially in these days of food scarcity. This development has automatically solved the pest problem and has also rendered the working of the Act even easier.

The Black headed caterpillar on coconut (Nephantis serinopa M). —A serious outbreak of this pest was reported from Mangalore during 1921 and on investigation it was found that the incidence was restricted to an area of about 5 miles round about Mangalore. The only measure that could be suggested to meet the emergent situation was a systematic cutting and burning of the infested fronds. This drastic method did not find any favour with the ryots. The aid of the Pest Act had, therefore, to be sought and enforced by the 1st January 1923 over the infested areas. The

process of cutting was later modified to a mere shaving off of the leaflets with a bill-hook specially designed for the purpose. The pest had, in the meanwhile, spread to other parts of South Kanara and later to practically all over the West Coast. The Act was, therefore, extended to all these areas by about 1927 and was in force till about 1931. Outbreaks were also reported in isolated localities of Krishna and Guntur districts. The legislative measure was introduced in these areas also and continued till the pest subsided to controllable limits. The administration of the Act was in the hands of the Revenue Department with the technical guidance of the Agricultural department.

The imposition of the Act was dispensed with by 1931 after the biological method of control was fairly established.

The red hairy caterpillar on dry crops (Amsacta albistriga M).—The only feasible remedy against this serious pest of dry crops is the hand picking of the moths, egg masses as well as the caterpillars. Isolated attempts of control did not give any appreciable relief, as the caterpillars have pronounced roving habits. The aid of the Pest Act was, therefore, sought to make it obligatory on the part of the ryots concerned to hand pick and destroy the various stages of the pest in their respective fields. This legislative measure was first introduced by about 1930 in some of the badly infested areas of South Arcot and was later extended to parts of North Arcot, Tanjore, Madurai as well as Northern Circars. The Act is still in force and is vigorously applied wherever necessary under the auspices of the Agricultural Department.

The cottony cushion scale on Wattles (Icerya purchasi Mask).—As already mentioned elsewhere, the scale broke out in all its virulence on the Nilgiris by 1928 and was particularly severe on broom (*Cytisus scoparius*) and St. John's wart (*Hypericum mysorensis*) over a limited area of about 150 acres at Fairlawns. These plants consist of only wild vegetation growing on waste lands serving practically no useful purpose. The infestation was so bad that it was feared the locality may serve as a fertile breeding ground for this obnoxious scale unless some drastic measures were immediately taken. An immediate destruction of all these shrubs was deemed urgent and the proposal executed by January–March 1929 with the aid of the Pest Act by the departmental officers. The mass breeding and colonization of the predator beetle *Rodolia cardinalis* had borne fruit by the end of 1929 and there was no more necessity to resort to the coersive method.

Similar legislative measures were contemplated for the later outbreak of the scale at Kodaikanals, but were not enforced since the predator beetles were available for release immediately.

The cattle fly (Stomoxys calcitrans. L.).—These flies are essentially pests of cattle. They generally rest round the eyes as well as on the body of the animals and apart from sucking their blood, cause considerable annoyance by the tickling sensation. They assumed a serious role in the Sidhout area by 1943. On investigation, they were found to breed in their millions in the groundnut cake applied as manure to the melon crop for which the locality is famous. The only remedy that could be suggested was the prohibition of the application of the cake manure and recommend some other organic or chemical substitutes. As a spontaneous response was not forthcoming from the melon growers, who are, as a class, poor people owning no cattle, the Pest Act prohibiting the application of the cake as manure was enforced during 1943 and is still in force. The enforcement of the Act is in the hands of the Agricultural Department.

The coffee stem borer (Xylotrechus quadripes *Ch.*)—The damage by these borers was severe in the lower Palnis, Sirumalais and Bodi hills. The control measures lie only in the prompt cutting and destruction of the infested plants. As the necessary response was not forthcoming from the planters, the aid of the Pest Act had to be invoked and the completion of the operation had to be made compulsory by the 15th August every year. The Act has been in force from 1916 onwards under the control of Agricultural Department.

The coffee berry borer (Stephenoderes hampei *Ferr.*).—This is a serious pest of coffee in other countries and had not so far been recorded in India. The first time live specimens of this beetle was noted in South India was when a parcel of seed coffee from East Africa was received for examination from the General Scientific Officer, United Planters Association of South India by the Government Entomologist during March 1927. A subsequent consignment of Arabica seeds imported into Bangalore from Belgian Cango by the Director of Agriculture, Mysore, was also reported to have been literally swarming with the beetles. The planters concerned rightly, feared that such indiscriminate imports might have already taken place with every possibility of the beetle having secured a foothold in India. An intensive survey of all the coffee growing areas in the south including Madras, Mysore, Travancore, Cochin, etc., was immediately taken up. A few cases of bored berries and occasional live specimens were recorded. The Madras Government was, in the meanwhile, appraised of the probable disastrous effects attendent on such unauthorized imports of the seed material. The gravity of the situation was immediately realized and further entry of unroasted coffee seeds was prohibited under the provisions of the Destructive Insects and Pests Act, Government of India. It subsequently transpired that the situation was not so serious, since the

beetle was not found to have established anywhere in this part of the country.

Plant quarantine regulations.—It is a matter of common experience that unrestricted imports of seed and plant material from other countries would result in the inevitable introduction of their specific insect pests along with them. To avoid such undesirable mishaps, the Government of India enacted certain legislative measures and passed the " The Destructive Insects and Pests Act, 1914 " authorizing the examination and treatment, if necessary, of any plant material imported in any of the ports. In due regard to this legislative measure, such consignments are being regularly examined and fumigated before they are allowed into the country. The Central Government have further stipulated that seed-material like, potatoes, coffee, rubber, sugarcane, cotton, etc., can be imported only by certain authorities and that too in certain ports only under specific conditions. The material in all these cases had to be fumigated with hydrocyanic acid by a competent authority. The execution of the work at the various ports situated in the Madras State was in the hands of the Customs authorities till 1944, and was later transferred to the Agricultural department. A few countries like America, Egypt, etc., also have enacted parallel legislations and bulk commodities like pepper, tamarind, cardamom, seed material, etc., have to be fumigated and certified by the Entomologist and Mycologist before they are exported.

Icerya purchasi, Mask—Prevention of its spread.—A glaring example of the inadvertent entry of a serious exotic pest into our shores is the cottony cushion scale—*Icerya purchasi.* This scale was first recorded on Wattles and other wild vegetation in 1928 on the Nilgiris in a serious form. It is needless to add that this insect should have been introduced much earlier along with some imported fruit or ornamental plants and left unnoticed until it developed to such serious proportions. The measures taken for the mechanical destruction of the scale have already been dealt with elsewhere. Having localized the incidence of the pest within the limits of the Nilgiris and Kodaikanal, the next step was to prevent its spread to other parts of the country. A comprehensive list of host plants of the scale was drawn up and none of these are permitted to be transported from the notified areas without scrutiny land fumigation. Four quarantine stations—Mettupalayam and Gudalur for the Nilgiris and Shembhaganur and Top Station for Kodaikanal—were opened during 1943 and a plant quarantine Inspector was posted in charge of each station. Work at Gudalur and Top Station was subsequently closed by January 1945 as the traffic was poor and the other two are still functioning as the situation warrants their presence. Appreciable quantities of wattle bark and consignments of fruit, ornamental plants, etc., are being intercepted and fumigated regularly.

The enforcement of the Pest Act towards the control of the different insect pests mentioned above was, on the whole, smooth and satisfactory. Wide publicity is being given regarding the necessity for these legislative measures and of the benefits of the methods suggested. The stipulations of the Act are generally executed more by persuasion and tact and the penal provisions are enforced only in very extreme cases. The methods being simple and effective, the concerned parties also have not failed to appreciate their benefits and little or no difficulty has, so far been experienced in enforcing these regulations.

I.—Insects affecting important cultivated plants in South India.

Insect.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			CEREALS.		
			PADDY (*Oryza sativa*).*		
† Paddy swarming caterpillar.	West Coast tracts, Northern Circars, Tirunelveli, Chingleput, Mysore.	The caterpillar defoliates seedlings in the nurseries and young plants in the fields.	*Spodoptera mauritia*, B. (Noctuid—moth).	Dust infested area with BHC D 025 at 20 lb. per acre. Flooding the field and destruction of caterpillars which gather on the plants also may be tried.	One of the worst pests of paddy in South India. (Colour Pl. XX, S.S.I.)
Paddy stem-borer.	Northern Circars, Ceded Districts, Ramanathapuram, South Malabar, Mysore.	The caterpillar bores into the paddy stem and kills the shoot or causes white ears.	*Schoenobius incertellus*, W. (Pyralid—moth).	Collect eggmasses and destroy dead seedlings in nurseries before transplantation. Difficult to control in later stages.	Sometimes reported as a serious pest from Northern Circars. (Col. Pl. XXIX, S.S.I.).
† Rice hispa ..	West Coast, Salem, Chingleput, Northern Circars, North Arcot, Chittoor and South Arcot.	The grub mines into the leaf tissue and the beetle scrapes the green foliage.	*Hispa armigera*, Ol. (Chrysomelid—beetle).	Use handnet and clip tips of seedlings, especially in the nurseries, where the pest starts. Dust BHC D 025 at 20 lb. per acre.	This small bluish spiny black beetle is often found bad in South Kanara. (Col. Pl. IX, S.S.I.).
Rice leptispa ..	Malabar; very rarely in other rice tracts.	Grub and adult feed on foliage.	*Leptispa pygmæa*, B. (Chrysomelid—beetle).	Same as hispa ..	This is a smooth bluish black beetle. (Fig. 165, S.S.I.).
† Rice bug ..	West Coast, Coimbatore, Tirunelveli and rarely in the Northern Circars.	The adult and young ones suck the juice from the tender ears and shoots.	*Leptocorisa acuta*, Th. (Coreid—bug).	Use handnet or big sweeping bag. Remove from the bunds other grasses on which the bug breeds. Dust BHC D 025 at 20 lb. per acre.	Bad in some years in the West Coast where it is called "*Chazhi*" in Malayalam; and *Bambuchu* in Kanarese; emits a bad smell. Found also on ragi, cumbu and other grasses now and then. (P.P.B., Pl. 11–5–8).

Rice grass-hoppers.	**West Coast, Mysore, Northern Circars, Tirunelveli, Chingleput and Coimbatore.**	**Feed on foliage and cut earheads.**	***Hieroglyphus banian*, F. and *H. orizivorus*, U. (in Ganjam) (Acridiid grass-hoppers).**	**Dust BHC D 025 at 20—25 lb. per acre.**	**Known as "*Pulpundu*" in South Malabar. (P.P.B., Pl. III-1-3.)**
Small grass-hopper.	**Common all over the province and rarely as a pest.**	**Same habits as rice-grasshopper.**	*Oxya velox*, F. (Acridiid—grasshopper).	**Same as for Rice grasshoppers.**	**Fig. 426, S.S.I.**
Rice case worm.	**West Coast, Coimbatore, Mysore, Chingleput and Visakhapatnam.**	**The caterpillars cut the leaves into pieces and make cases in which they live and feed on the paddy leaves.**	***Nymphula depunctalis*, Gr. (Pyralid—moth).**	**Flood the field, shake the plants with a long pole to make the cases drop down. Drain the water or spray a thin film of kerosene oil on the water to kill the worms in the cases. Spray DDT 0·1 per cent or dust 5 per cent.**	**The injury done to paddy is known as *Kokku novu* in Tamil. (Col. Pl. XXXII, S.S.I.)**
Rice leaf-folder.	**West Coast tracts and Ganjam.**	**Caterpillar rolls up leaf-tips and feeds on the green matter.**	***Cnaphalocrocis medinalis*, *Gr.* (*Pyralid*—moth).**	**Clipping the leaf-rolls at the early stages.**	**Sometimes sporadic causing appreciable harm. (P.P.B., Pl. V-5.)**
Paddy gall-fly.	**N. Circars, Tanjore, Ramanathapuram and West Coast.**	**The maggot bores into the stem, attacks bud of shoots and causes galls known as silver shoots. No ears are formed.**	***Pachydiplosis oryzæ*, W. (Cecidomyiid—fly).**	**No effective remedy known yet; keep the field bunds clear of wild grasses in which this insect often breeds.**	**The disease is called "*Anaikombu*" in Tamil, "*Kodu*" in Telugu. (P.P.B., Pl. IV-1.)**
Paddy mealy-bug.	**South Arcot, Tiruchirappalli, Salem, Tanjore, Coimbatore and rarely in Northern Circars.**	**Colonies of this minute insect infest the inside of the paddy leaf sheaths and suck up the plant sap.**	*Ripersia oryzæ*, Gr. (Coccid—mealy bug).	**No effective remedy known. As a preventive, the early attacked plants may be removed and burnt to prevent spread. Infested seedlings may be eliminated while transplanting.**	**The disease is known as "*soorai*" in Tamil and is sometimes bad in Tiruchirappalli, Tanjore and South Arcot. Affected fields show patches of plants with disease called "*Dumpu tegulu*" in Northern Circars. (P.P.B., Pl. IV-2.)**

*** For fuller information on paddy pests the bulletin on paddy insects (Madras Agrl. Dept. Bulletin No. 25, 1931) may be consulted.**
† See also departmental leaflets Nos. 40, 41 and 42 on these three pests.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insect.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			CEREALS—*cont.*		
			PADDY (*Oryza sativa*)—cont.		
Circars jassid.	Northern Circars ..	Occasionally appearing in swarms; suck young plants and make them fade in patches in fields.	*Deltocephalus dorsalis*, M. (Jassid—bug).	Spray DDT 0·1 per cent or dust 5 per cent. Netting and light trap also effective.	Small-sized sporadic leaf-hopper pests in different tracts appearing in some years and causing some damage. For figures *see* P.P.B., Pl. VI.
Krishna leaf-hopper.	Nellore, Krishna, Malabar and Cochin.	Do.	*Nilaparvata sordescens*, *M.* (Delphacidae—fulgorid bug).	Do.	
Leaf-hopper ..	Nellore	....	*Nysia atrovenosa*. L. (Cixiidæ—fulgorid—bug).	Do.	
North Malabar leaf-hopper.	North Malabar ..	Occasionally appearing in swarms; suck young plants and make them fade in patches in fields.	*Erythroneura subrufa*. M. (Fulgorid—bug).	Do.	
Paddy leaf-weevil.	Coimbatore ..	Feeding on paddy leaves.	*Athesapeuta oryzæ*, M. (Curculionid—weevil).	Hardly a pest	Another grey weevil, *Myllocerus dentifer*, F. is occasionally seen in some places on paddy but rarely doing serious harm. (P.P.B., Pl. VII-2.)
Striped leaf-beetle.	Malabar	Do.	*Oides affinis*, F.* (Chrysomelid—beetle).	Hardly a pest, though found in numbers sometimes.	Reddish brown beetle with a black mark on each forewing. Fig. (P.P.B., Pl. VII-5.)
Yellow blister beetle. Green blister beetle.	In most tracts ..	Feed on the flower heads, chiefly pollen.	*Gnathospastoides rouxi*, C. *Lytta tenuicollis*, Pall *Epicauta sp.* (Cantharid—beetles).	Easily checked by netting or driven by smoke; beetle remain on plant only for a short time generally.	Figs. 147, 148, 154, S.S.I.
Blue black blister beetle.	South Kanara ..	Do.			

Paddy Eupterotid.	Agency tracts, Visakhapatnam.	Caterpillars feeding on foliage.	*Nisaga simplex*, W. (Eupterotid—moth).	Rarely a pest	Stout brown moth.
Paddy surface grass-hoppers.	Coimbatore, Anantapur, etc.	Feeding on young plants and doing some appreciable damage especially in small areas and nurseries.	*Acrotylus humbertiana*, S. *Heteropternis respondens*, W., *Aelopus affinis*, B., *Locusta danica*, L., *Pyrgomorpha conica*, [O. (Acriidiidæ—grasshoppers).	Dust BHC D·025 at the rate of 20–25 lb. per acre.	Chiefly found in nurseries. All are small grasshoppers, greenish, greenish brown or yellowish brown in colour.
Rice stem fly.	Coimbatore ..	Larva boring in stem ..	*Atherigona sp.* (Anthomyiid—fly).	Only preventive methods feasible in this case.	The insect is a minute fly noted only now and then in small numbers.
Rice flea beetle.	Godavari	Causes dead-hearts in nurseries.	*Chaetocnema sp.* (Halticid—beetle).	Do.	Very minute active beetles ; rarely serious.
			RATS ON PADDY.		
Mole rat ..	Common all over the Province.	Crop in the nursery as well as the shot-blade stage attacked for the sake of leaves and also the sweet juice exuding from the plants. When mature, earheads are cut in large numbers and stored in burrows for consumption.	*Gunomyskok*, G. (Muridae).	Use zinc phosphide as poison bait ; mix the chemical with 20 parts of any rat feed, preferably popped rice and expose the bait in various places in the field. Catching by professionals and use of bow-trap also effective.	Adults recognised by their compact build, greyish brown colour and shorter tail devoid of hairs ; ferocious by temperament and never come out of burrows when disturbed ; tortuous burrows are excavated in the field bunds.
Grass rat ..	Tanjore delta ..	More or less same as above, but not so serious.	*Millardia meltada*, G. (Muridæ).	Do.	Small in size, brownish grey body with white abdomen. Burrows shallow with two or three openings, one of them being closed with a padding of grass, covered by a layer of earth.

* The blue leaf beetle *Haltica cyanea*, J., is often found in numbers on paddy ; it is not a pest of paddy but breeds on the plant *Ammania* in Paddy fields.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			CEREALS—*cont.*		
			PADDY (*Oryza sativa*)—cont.		
Antelope rat or the Gerbil.	In all tracts ..	More or less same as above, but not so serious.	*Tatera cuvieri*, W. (Muridæ).	Use zinc phosphide as poison bait; catching and destruction by professionals also effective.	Buff colour, bigger eyes and ears, long tail with tuft of hair; very agile, run fast and jump well, gregarious in habit.
			CHOLAM (*Andropogon sorghum*).		
Cholam stem-borer.	Northern Circars, Ceded districts, Coimbatore and Tirunelveli.	Caterpillars bore through stem, killing young plants and damaging older stems.	*Chilo zonellus*, S. and C. Sp. Pyralid—moths).	Collect and destroy dead-hearts and destroy stubble after harvest. Difficult to check on old plants.	More injurious to young plants; also found on maize, ragi, sugar cane, etc. Fig. 300, S.S.I.
Cholam earhead bug.	Ceded districts, Coimbatore, Tirunelveli and Northern Circars.	The active green insects suck up the sap from tender earheads.	*Calocoris angustatus*, L. (Capsid—bug). Another capsid, *Megacoelum syramineum*, W. is also found with this bug occasionally.	At Coimbatore, crops sown before 15th March escape damage. Dust BHC D025.	Sometimes serious in Coimbatore and the Ceded districts. Fig. 376, S.S.I. called "*Aggipurugu*" in Ceded districts.
Red hairy caterpillar.	In all dry areas especially in red soil tract of South Arcot, Salem, Ceded districts, Tiruchirappalli and Mysore.	Feeding on every part of the plant and skeletonising it.	*Amsacta albistriga*, W. (Arctiad—moth).	Hand pick adults and eggmasses, and later caterpillars also if necessary.	Not so bad as on cumbu or groundnut. *See* Mysore bulletin on the "*Kambli hula.*" Pl. XVII, S.S.I. A pest of many other plants.
Cholam fly ..	Coimbatore, Mysore and adjacent tracts.	Larva attacks young seedlings causing dead-hearts.	*Atherigona indica*, M. (Anthomyiidæ—fly).	Dead seedlings to be pulled out and destroyed while the field is thinned; seed rate may be slightly increased in localities subject to infestation.	Generally attacks only seedlings. (Fig. 215, S.S.I.)

Cholam shoot bug.	Coimbatore, Ceded districts and Northern Circars.	Colonies of this small insect infest tender leaves and suck the juice.	*Pundaluoya simplicia*, D (Fulgorid—bug).	No effective remedy known; pull out first attacked plants to check spread; in valuable plots spraying may be done with a contact insecticide.	Badly infested plants appear as though scorched by fire. Ants are found visiting these insects. They are often found in company with plant-lice. (Fig. 382, S.S.I.)
Shoot caterpillar.	Coimbatore ..	Feeding on foliage from inside leaf shoots.	*Cirphis unipuncta*, M. and rarely *C. loreyi*, D. (Noctuid—moths).	Handpicking or dusting shoots with arsenates if necessary.	Not a serious pest generally; a stout smooth caterpillar, one of the army or cutworms. Pl. XVIII, S.S.I.
Leaf-roller ..	In all dry tracts ..	Rolling leaf and feeding from inside roll.	*Marasmia trapezalis*, G. (Pyralid—moth).	Of minor importance ..	A yellowish brown moth with wavy marks on wings. Pl. XXXIII, S.S.I.
Leaf weevil ..	Coimbatore, Northern Circars and Ceded districts.	Feeding on leaves ..	*Myllocerus discolor*, B. (Curculionid—beetle).	Do. ..	A greyish brown sp. fairly common everywhere: the grub is often found feeding on roots of cholam, ragi, etc.
Cholam aphid.	Coimbatore and Northern Circars.	Found in colonies inside tender shoots sucking up juice.	*Aphis maidis*, F. (Aphididæ—bug).	Dust tobacco powder, if necessary.	Rarely a pest. Commonly kept in check by predatory insects.
Earhead caterpillar.	Tanjore	Feeding on the ripening grains.	*Eublemma silicula*, S. (Noctuid—moth).	Very rarely a pest ..	The adult insect is a small pale brown moth.
Earhead webber.	Ceded districts and Coimbatore.	Caterpillars found webbing the grains in the earhead and feeding on the grains.	*Stenachroia elongella*, H. (Pyralid—moth).	Rarely a pest and only of local importance.	Fig. 296, S.S.I.
Plant bugs ..	Northern Circars, Tirunelveli, and many other parts.	Attacking tender parts, especially the ripening earheads and sucking the plant sap.	*Nezara viridula*, L., *Dolycoris indicus*, S., *Agonoscelis nubila*, F., *Piezodorus rubrofasciatus*, F. (Pentatomid—bugs).	Handpicking and netting.	Figs. 352, 347 and 351, S.S.I. Found mostly confined to the earheads.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			CEREALS—*cont.*		
			CHOLAM (*Andropogon sorghum*)—cont.		
Earhead chafers.	Ceded districts and Coimbatore.	Feeding on the ears and pollen.	*Anatona stillata*, N., *Oxycetonia versicolor*, F., *Chiloloba acuta*, W. *Protaetia aurichalceae*, F. (Cetonidæ—chafer beetles).	These beetles are conspicuous and can be easily checked by handpicking and netting, but they are pests very rarely.	Figs. 122, 123 and 124, S.S.I.
Earhead blister beetles.	Do.	Do.	*Gnathospastoides rouxi*, C., *Lytta tenuicollis*, P. (Cantharid—beetles).	As on paddy	*See* under paddy.
Surface grass-hopper.	Do.	Attacking young plants and often cutting them down.	*Chrotogonus saussurei*, B. (Acridiid—grass-hopper).	Dust BHC D025 at 20–25 lb./acre.	Small active creatures often resembling the soil in colour.
Cholam gallfly.	Coimbatore ..	Breeding inside the tender grains of cholam and making seeds empty.	*Contarinia andropogonis*, Felt. (Cecidomyid—fly).	No remedy known ..	Sometimes sporadic.
Cholam mite ..	In most cholam tracts.	The leaves are turned sickly red by colonies of the mite feeding on the leaf tissue.	*Paratetranychus indicus*, H. (Acari—mite.)	Dusting of fine powdered sulphur.	An occasionally serious pest. Not an insectt.
Green blister beetle.	In most tracts ..	Feed on the flower heads.	*Lytta tenuicollis*, P., (Cantharid).	Not a serious pest; control measures same as for paddy.	....
			RAGI (*Elusine coracana*).		
Pink borer ..	Coimbatore, Ceded districts and Northern Circars.	Caterpillar bores into stem and kills central shoot.	*Sesamia inferens*, W. (Noctuid—moth).	Same measures as suggested for cholam stem-borer above.	Also found on wheat, maize, sugarcane and cholam. The caterpillar has a uniform pink colour. (Pl. XXI, S.S.I.)

White borer ..	Coimbatore and Ceded districts.	Caterpillar bores into lower portions of the stem.	*Saluria inficita*, W. (Pyralid—moth).	Same as above; the moth comes to light and so light traps may be tried early in the nurseries to trap moths about to lay eggs.	The borer is cream white in colour. Noted on paddy in Mysore. (Fig. 304, S.S.I.)
Cholam stem-borer.	In all tracts ..	Bores into stem as in cholam.	*Chilo zonellus*, S. (Pyralid—moth).	As on cholam	*See* under cholam stem borer.
Black hairy caterpillar.	Coimbatore ..	Eats leaves and earheads.	*Estigmene lactinea*, Cr. (Arctiad—moth).	Collect the caterpillars in the early stages by jerking the infested leaf over a pan of water containing a little kerosene.	Known as the wooly bear caterpillar; found on cumbu also. (Fig. 230, S.S.I.)
Root lice ..	Coimbatore tract ..	The minute insects attack roots and suck up the juice.	*Tetraneura hirsuta*, B. (Aphidid—bug).	Irrigate with water mixed with a little of kerosene amulsion or Crude oil emulsion.	Small white insects found in numbers attached to the underground roots and rootlets. (Fig. 390, S.S.I.)
Earhead caterpillar.	Coimbatore and Mysore.	Caterpillar attacks earheads in stacks soon after harvest.	*Simplicia robustalis*, G. (Noctuid—moth).	Thrash the harvested crop soon after harvest.	Found as a pest of thatching material in Coimbatore.
Leaf Noctuid.	Coimbatore, Visakhapatnam and many other places.	Sometimes bad in nurseries feeding on the young plants.	*Laphygma exigua*, Hb. (Noctuid—moth).	Netting or dusting arsenates.	Fig. 240, S.S.I.
Thrips ..	Coimbatore ..	Sometimes bad in nurseries; sucking up the plant juice from seedlings.	*Heliothrips indicus*, B. (Thripidae—thrips).	Flood the nurseries or spray tobacco decoction.	Very minute insects. *See* Fig. 1, Thy. Mem.
Grasshoppers.	Coimbatore, Tirunelveli and Ramanathapuram.	Feeding on foliage of the young plants.	Several different kinds noted such as spp. of *Oedaleus*, *Aeolopus*, *Chrotogonus*, *Acrotylus*, etc.	Dust BHC DO 25 ..	These do more harm when the crop is young when they can be easily checked.
Flea beetles ..	Coimbatore ..	Biting holes in the tender foliage.	*Chaetocnema sp.*, a leaf-beetle. *Lema downsei*, B. is also found. (Hispid beetles).	Netting or dusting of arsenates.	Very minute and active beetles; occasionally doing some damage.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			CEREALS—*cont.*		
			CUMBU (*Pennisetum typhoideum*).		
Red hairy caterpillar.	Coimbatore, Tirunelveli, South Arcot, Salem and Ceded districts.	Feeds on the leaf, earheads and stem.	*Amsacta albistriga*, W. (Arctiad—moth).	Same as the one noted above on cholam.	Sometimes a bad pest of cumbu and groundnut. (Pl. XVII, S.S.I.)
Green plant-bugs.	Tirunelveli, Ramanathapuram and Coimbatore.	Suck the juice from the tender parts.	*Nezara viridula*, L. *Eusarcocoris guttiger*, Th. (Pentatomid—bugs.)	Easily checked by hand-picking or by using hand-nets. The eggs and nymphs which are easily found out can also be destroyed promptly.	Nezara known as "*Pachalai*" and "*Navai puchi*" in Tamil. Green and flattish with the buggy smell. The other bug is small brownish insect.
Black hairy caterpillar.	Coimbatore ..	Feeds on the leaf, earheads and stem.	*Estigmene lactinea*, Cr. (Arctiad—moth).	Same as noted above on ragi.	Not commonly found.
Deccan grasshopper. ..	Ceded districts and Northern Mysore.	Feeding on all parts of the plant.	*Colemania sphenarioides*, B. (Acridiid—grasshopper).	Dust BHC 10 per cent ..	A wingless grasshopper also found on cholam, tenai, etc. So far confined to Ceded districts
Tirunelveli wingless grasshopper.	Coimbatore and Kovilpatti. ..	Feeding on all parts of the plants.	*Orthacris simulans*, Bol. (Acridiid—grasshopper.)	Do. ..	A small wingless grasshopper.
Earhead beetles.	Coimbatore, Ceded districts, Tirunelveli, South Arcot and Northern Circars.	Eat up the flower heads and ripening ears.	*Gnanathospastoides rouxi*, C. *Lytta tenuicollis* P. (Canthrid—beetles).	The beetles are sluggish and so can be handpicked or collected in handnets easily. They can also be smoked out of the fields.	These generally appear when the plants are in flower and disappear very soon. (Figs. 153, 148, 147, S.S.I.)
Seed bug ..	Krishna district ..	Sucks the grain soon after harvest.	*Aphanus sordidus*, F. (Lygaeid—bug).	Collect bugs with nets or cover harvested seeds.	*See* under groundnut.

		TENAI (*Setaria italica*).			
Deccan grass-hopper.	Bellary district and North Mysore.	Completely eats up the young and grown-up plants.	*Colemania sphenarioides*, B. (Acridiid—grasshopper).	Dust BHC 10 per cent.	Very serious during certain years in Bellary district; does more harm to this crop than others in this tract.
Tenai erotylid.	Coimbatore ..	Larva bores into stem ..	*Anadastus parvulus*, W. (Erotylid—beetle).	Destruction of first attacked shoots and collection and destruction of the beetles when found.	A blue and red beetle; not an important pest.
Leaf-weevils ..	South Arcot, Coimbatore and Ceded districts.	Eating the leaves ..	*Myllocerus dentifer*, F., and *M. transmarinus* H. (Curculionid—weevils).	Handpicking and netting. The beetles could be jarred from the plants over a bucket of water and kerosene.	Though these are of minor importance they sometimes appear sporadically as pests of millets and defoliate the plants.
		MAIZE (*Zea mays*).			
		Almost all insects found on cholam attack maize also; of these maize pests the chief are—			
Pink borer ..	Coimbatore, Northern Circars and Ceded districts.	Stem-borer	*Sesamia inferens*, W. (Noctuid—moth).	Same as ragi pink borer; same measures to be adopted.	*See* under ragi pink borer.
Cholam shoot bug. ..	Coimbatore, Ceded districts and Northern Circars.	Sucks the juice from tender parts.	*Pundaluoya simplicia*, D. (Fulgorid—bug).	*See* under cholam	*See* under cholam.
Cholam stem-borer.	Do.	Do.	*Chilo zonellus*, S. (Pyralid—moth).	Do.	Do.
Leaf Noctuid.	Coimbatore, Northern Circars, Salem, etc.	Feeds on the foliage and sometimes serious.	*Laphygma exigua*, H. (Noctuid—moth).	Handpick or net caterpillars or dust arsenate on infested plants.	A sporadic local pest in some tracts.
Grasshopper	Coimbatore and Northern Circars.	Feeding on green parts	*Orthacris elegans*, Bol. (Acridiid—grasshopper).	Dust BHC D·025 ..	Wingless grasshoppers.
		MILLETS (*Panicum spp.*).			
Panivaragu flea beetle.	Coimbatore and Guntur.	Larva and adults feed on foliage and also cause dead-hearts in nurseries.	*Chaetocnema pusaensis*, M. (Halticid—beetle).	Netting or dusting of arsenates.	Very minute active beetles, occasionally found in numbers.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			CEREALS—*cont.*		
			WHEAT (*Triticum vulgare*).		
Stem-borer ..	Coimbatore and Bellary.	Caterpillar bores into stem and kills shoot.	*Sesamia inferens*, D. (Noctuid—moth).	This is the same as the ragi pink borer and the same measures will apply.	See under ragi pink borer.
Plant lice ..	Do.	The minute insects suck up the juice from tender parts.	*Toxoptera graminum*, R. (Aphid—bug).	If badly infested, the plants may be sprayed with crude oil emulsion if the crop is a valuable one, but generally the pest is checked by predators.	Minute insects found in colonies and visited by ants and predators like lady-bird, beetles, hover flies and chrysopa.
Termites ..	Do.	The ants eat up roots of growing plants.	*Microtermes obesis*, H. (Termitidae—white-ant).	Mix contact insecticide with irrigation water.	
			SUGARCANE (*Saccharum officinarum*).		
Cane stem-borers.	Northern Circars, Coimbatore, South Arcot, Chittoor and South Kanara.	Boring into stem, killing young shoots, and damaging growing canes.	Two or more species are found. Chief species are *Argyria sticticraspis*, H., and *Diatroea venosata*, W. (Pyralid—moths).	The injury is more serious in young plants. Pulling out and destroying dead-hearts will check the spread of the pest. Very little damage done to older plants.	The borers form the most important of cane pests in the province.
Cane white borer.	Coimbatore, South Arcot and Bellary.	The white caterpillar bores into the stem from the topshoot unlike other borers.	*Scirpophaga xanthogastrella*, W. (Pyralidae—moth).	Not so serious as the other borers. In early stages the attacked top shoots may be clipped. Egg-masses easily made out can be collected.	Figs. 302, 303, S.S.I. *S. nivella*, F., is also sometimes noted in Godavari.

Termites ..	In almost all cane tracts.	Bore into the planted setts underground kill the tender shoots and buds.	*Odontotermes obesus*, R. (Termitidae—white-ant). The ant *Dorylus* is also found sometimes.	Fields should be cleared of white-ant nests before planting. Disease-free setts should be planted. Fields showing attack may be irrigated with water containing crude oil emulsion.	The pest is often serious in virgin fields and the setts and seedlings suffer much.
Cane fly .. **(Cane leaf-hopper).**	South Kanara, Coimbatore, Northern Circars, South Arcot and Godavari.	Sucks up juice from tender portions.	*Pyrilla perpusilla*, W. (Fulgorid—bug).	Leaves containing egg masses and nymphs can be clipped and the pest easily controlled if attended to in time. Dust. B.H.C.DO 25.	A straw coloured active insect with the head drawn forwards. Serious only in rare cases and in small area. (Fig. 381, S.S.I.)
Cane mealy-bug.	Coimbatore, South Arcot and Northern Circars.	Numbers of these small insects settle at the lower portions of the cane stem and suck the juice.	*Ripersia sacchari*, Gr. (Coccid—Mealy bug).	Nothing effective can be done except by using healthy seed and treating first attacked canes as a preventive.	Colonies of this insect are found attached to the lower nodes of the cane enclosed by old leaf-sheaths.
Cane scale insect.	Salem	Cover stem inside of leaf sheaths and suck the juice.	*Aclerda japonica*, N. (Coccid—scale insect).	Spraying with contact insecticide.	Rarely a pest.
Cane mealy wings.	Coimbatore, South Arcot and Godavari.	Sucks up juice from leaves and makes the crop sickly and stunted.	*Aleurolobus barodensis*, Msk. *Neomaskellia bergii*, Sign. (Aleurodidae—Mealy wings).	Prune badly infested leaves and spray contact insecticide.	Fig. 394, S.S.I.
Cane hesperid.	Coimbatore, South Arcot and Northern Circars.	Caterpillar feeds on the leaves.	*Telicota augias*, L. (Hesperid—butterfly)	Handpick caterpillars and net butterflies.	Fig. 294, S.S.I.
Cane leaf-hopper.	Do.	Found in numbers on leaves. Leaf-sucking bugs.	*Assamia moesta*, W. (Fulgorid—bug).	Not a pest usually though found in numbers.	Small black fly-like insects. Fig. 380, S.S.I.
Cane hispid ..	Coimbatore and Northern Cirsars.	Grubs and adults feeding on tender foliage.	*Phidodonta modesta*, W. (Hispid—beetle).	Hardly a pest	Insects similar to rice hispa plate IX, S.S.I.
Cane thrips ..	Coimbatore and South Arcot.	Sucking juice from tender leaf tips and making them curled and rolled up.	*Bregmatothrips ramakrishna* B. Thripidae—thrips,	Crippling the curled leaves. A very minor pest.	Minute small insects of a dark brown colour. *See* page 267, Thy. Mem.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			SUGARCANE (*Saccharum officinarum*)—*cont.*		
Cane root lice .	Coimbatore ..	Attack roots	*Tetraneura ulmi, coimbatorensis*, G.	See under ragi root aphis.	Noted only in Coimbatore till now.
Cane grasshopper.	Northern Circars ..	Feed on foliage	*Hieroglyphus banian*, F. (Acrididae).	Dust B.H.C. DO 25 at 20-25 lb. per acre.	This is more popularly known as rice grasshopper but attacks cane also.
			PULSES.		
			REDGRAM (*Cajanus indicus*).		
Gram caterpillar.	Throughout South India.	Eats leaves and bores into the seed pods eating up the seeds.	*Heliothis obsoleta*, Fb. (Noctuid—moth).	In early stages handpicking may be tried; difficult to check when too late and in large areas.	Also attacks groundut and bengalgram. A stout cylindrical greenish caterpillar. (Fig. 235, S.S.I.)
Plume moth ..	Do.	The same damage as above.	*Exelastes atomosa*, W. (Pterophorid—moth).	Same as above	A small light green caterpillar covered with small spines and hairs. The moth has plumed wings. (Pl. XXXVIII, S.S.I.)
Red hairy caterpillar.	Mysore	Feeding on all green parts.	*Amsacta albistriga*, W. (Arctiad—moth).	See under cholam	Often bad on redgram in Mysore.
Pod-fly ..	Do.	The small maggot bores into the seed pod and damages the seeds.	*Agromyza obtusa*, M. (Agromyzid—fly).	No effective remedy known.	The adult insect is a very small bluish blackfly like the housefly but much smaller. (Fig. 216, S.S.I.)
Bud weevil ..	Coimbatore and Northern Circars.	The grub and the adult feed on the flowers and buds and destroy them preventing pod formation.	*Ceuthorhynchus asperulus*, F. (Curculionid—weevil).	Shake the shoots and collect the weevils on infested flower buds, or dust with arsenate powder.	Small greenish brown weevil. (Fig. 194, S.S.I.)

Gram pod bug.	Coimbatore, Ceded Districts and Northern Circars.	The adult and young ones suck the juice from young seed pods.	*Clavigralla horrens*, D. Sometimes also C. *gibbosa*, S.	Collect with nets and destroy eggs on pods on leaves.	An active grey brown insect with sharp shoulder spines.
Leaf-weevil ..	Coimbatore, Ceded Districts and South Arcot.	Leaf-eater	*Episomus lacerta*, F., and *Myllocerus spp.* also sometimes found. (Curculionid—weevils).	Collect with handnets ..	Stout ashy grey weevil fairly common on most pulses.
Tussock hairy caterpillar.	Coimbatore and Northern Circars.	Caterpillar feeding on leaves and tender shoots.	*Euproctis fraterna*, M. (Lymantrid—moth).	Handpick leaves containing the larvae feeding together in numbers and if necessary spray or dust arsenate.	A reddish hairy caterpillar, often found on castor and roses also.
Orange-banded blister beetle.	In all tracts ..	Feeding on flowers and tender shoots.	*Mylabris pustulata*, Th. (Cantharid—beetle).	Easily checked by handpicking or netting. The beetles are slow fliers.	The beetle is often found on different kinds of red and yellow flowers such as *Hibiscus*, prickly-pear, gogu, etc. (Fig. 149, S.S.I.)
Crab caterpillar.	Coimbatore, Malabar and Ganjam.	Caterpillar feeds on leaves and shoots.	*Stauropus alternus*, W. (Notodontidæ—moth).	Generally not a serious pest. Can be handpicked. Often heavily parasitised.	A curiously looking greyish brown caterpillar. (Fig. 279, S.S.I.).
Leaf and shoot folder.	Coimbatore and Northern Circars.	Caterpillar webs together leaves and top shoots.	*Eucosma critica*, Mey. (Eucosmid—moth).	Handpick webbed leaves and shoots.	A minor pest. The caterpillar is a short pale yellowish creature. (Pl. XXXIX, S.S.I.).
Leaf roller ..	In all redgram tracts.	Caterpillar rolls the leaf-tips.	*Gracillaria soyella*, D. (Gracillariad—moth).	Hardly a pest	....
Blue butterfly.	In all tracts ..	The larva feeds on the pods and flowers.	*Polyommatus boeticus*, L. (Lycænid—butterfly).	A minor pest, Butterflies can be netted.	Small bluish butterfly with short stout fleshy larva. (Fig. 288, S.S.I.)
Scale insects ..	Coimbatore and Northern Circars.	Infest shoots and stem in colonies and suck juice.	*Ceroplastodes cajani*, M. and *Lecanium longulum*, D. (Coccid—Scale insects.	Prune badly-infested shoots and spray others with contact insecticide.	See Fig. 400, S.S.I.
Leafcutter bee.	All over South India.	Cuts pieces of tender leaves and carries the pieces to the nest.	*Megachile anthracina*, Gm. (Apidae—bee).	May be caught by nets or the leaves can be dusted with arsenates.	This is also noted in plants like roses, Cassia, etc., in gardens.
Bruchid	Coimbatore and Mysore.	Feeding and breeding on pods in fields.	*Bruchus theobromæ*, L. (Bruchid—beetle).	Collect beetles with nets..	One of the few pulse-beetles found in the field also.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			PULSES—*cont.*		
			REDGRAM (*Cajanus indicus*)—cont.		
Lab-lab bug ..	Coimbatore, Mysore and Northern Circars.	Sucking plant sap from tender parts.	*Coptosoma cribraria*, F. (Pentatomid—bug).	Collect bugs by nets ..	Small greenish bug found on lab-lab, Pongamia in swarms, with a bad smell.
Verpuchi ..	South Arcot, Bellary and Coimbatore.	Grub of beetle bores into stem close to the roots.	*Sphenoptera perotteti*, G.L. (Buprestid—beetle).	Rarely a serious pest of redgram, usually a pest of groundnuts; only preventives possible.	*See* under groundnut.
			BENGALGRAM (*Cicer arsetinum*).		
Gram caterpillar.	Coimbatore, Ceded Districts and Northern Circars.	Eating leaves and the seeds by boring into pods.	*Heliothis' obsoleta, Fb.* (Noctuid—moth).	Same as the one on redgram (see above). Same control measures.	It is a major pest of Bengalgram in South India. The pest is sometimes checked by parasitic wasps
			BLACK AND GREEN GRAMS (*Phaseolus radiatus* and *P. mungo*).		
Pod borer ..	All over South India.	Caterpillar damaging seeds.	*Maruca testulalis*, G. (Pyralid—moth).	Only preventive method of plucking off first attacked pods practicable in the early stages.	Found also on other grams and sunnhemp. Not a serious pest. (Fig. 305, S.S.I.).
Sphinx cater pillar.	Northern Circars and Coimbatore.	Defoliating the crop ..	*Herse convolvuli*, L. (Sphingid—moth).	Eggs and caterpillars which are very conspicuous on the plants can be handpicked and destroyed; the infested fields may be ploughed up after harvest to kill undergound pupæ.	Stout big caterpillar. Sometimes causes serious damage. (Fig. 272 S.S.I.).
Green leaf-caterpillar.	All over the province.	Feeding on leaves ..	*Azazia rubricans*, B. (Noctuid—moth).	A minor pest. In bad cases arsenates may be used.	Fig. 254, S.S.I.

Pod weevil ..	Coimbatore and Mysore.	Feeding on leaves and breeding in pods.	*Apion amplum*, F. (Curculionid—beetle).	Collect the beetles or dust plant with arsenate if serious.	Very small ant-like black insects, often bad on blackgram in Mysore.
Plant lice	All over the province.	Crowding on tender shoots and sucking the sap.	*Aphis sp.* (Aphid—plant-louse).	May be sprayed with a contact poison in valuable plots. Commonly checked by predators.	Colonies of the minute insect often cause some appreciable damage.
Leaf weevils ..	Coimbatore, Coorg, Ceded Districts, Salem, Tirunelveli, etc.	Feeding on the leaves and shoots.	*Alcides collaris*, *P. A. fabricii*, F. (Curculionid—weevils).	Collect weevils by the hand.	Rarely serious. (Figs. 197 and 195, S.S.I.).
Green-gram weevil.	Ceded Districts ..	Damaging the seeds ..	*Pachytychius mungonis*, M. (Curculionid—weevil).	No effective remedy known except preventive method of picking of attacked pods.	Also attacks daincha pods in Coimbatore. (Fig. 194, S.S.I.)
			HORSEGRAM (*Dolichos biflorus*).		
Pod-borer ..	All over South India.	Caterpillar damaging seeds.	*Etiella zinkenella*, Tr. (Pyralid—moth).	Only preventive method of plucking off first attacked pods practically in the early stages.	Found also on other grams and sunnhemp. Not a serious pest (Fig. 305, S.S.I.)
Leaf caterpillars.	Coimbatore, Ceded Districts and Northern Circars.	Feeding on foliage ..	*Azazia rubricans*, B. (Noctuid-moth), *Nacoleia* (*Lamprosema*) *indicata*, Fb. (Pyralid—moth).	Generally of minor importance. Spraying or dusting with arsenates in serious attacks.	Sometimes occur as sporadic pests. (Figs. 254 and 310, S.S.I.).
Hairy caterpillar.	Mysore	Do. ..	*Diacrisia obliqua*, W. (Arctiad—moth).	Handpicking of leaves containing the gregarious larvæ.	Noted sometimes serious in Mysore.
			COW PEA (*Vigna catjang*).		
Stem fly ..	Coimbatore and Tirunelveli.	Maggots bore into stem of plants.	*Agromyza phaseoli*, Coq. (Agromyzid—fly).	No effective remedy known.	Similar to the redgram pod fly in general appearance and habits. (Fig. 217, S.S.I.).
Plant lice ..	In all tracts ..	Sucking up the juice ..	*Aphis sp.* (Aphididae—bug).	May be sprayed with a contact poison in valuable plots; commonly checked by predators.	Colonies of this minute insect often cause some appreciable damage.
Blister beetles.	Do. ..	Feeding on flowers ..	The common spp. noted on cereals are *Cantharis setaceae*,	Handnet beetles	The last one was once found bad in Godavari in 1919.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			PULSES—*cont.*		
			Cow Pea (*Vigna catjang*)—cont.		
Blue butterfly.	In most tracts ..	The caterpillars bore into the seed capsules.	*Euchrysops cneyus*, F., and *Polyommatus boeticus*, L. (Lycaenid—butterflies).	Only preventive method, plucking off early attacked pods. The caterpillars may also be handpicked in early stages. The butterflies can be netted.	The caterpillars are soft and fleshy and the butterflies small and bluish, found often flying in the fields. (Pl. XXVI, Fig. 288, S.S.I.).
Leaf caterpillar.	In all tracts ..	Leaf feeding	*Azazia rubricans*, B. (Noctuid—moth).	Handpick caterpillars and spray stomach poison when needed.	A looper caterpillar occasionally found on most pulses. (Fig. 254, S.S.I.).
Pod bugs ..	Coimbatore and Malabar.	Sucking sap from pods and tender parts.	*Riptortus pedestris*, Fb., *R. linearis*, F., and *Anoplocnemis phasiana*, F. (Coreidæ—bugs).	Catch bugs with nets and destroy eggs laid on pods and leaves which can be easily seen.	Large-sized active bugs found on other pulses also. (Figs. 364 and 360, S.S.I.).
Stem-borer beetle.	Travancore ..	Larva boring into stem.	*Oberea sp.* (Cerambycid—beetle).	Destroy badly-infested plants and beetles (if found.)	Minor pest.
			Field Bean (*Dolichos lablab*).		
Plant lice ..	In most tracts ..	Sucking up the juice ..	*Aphis medicajenis*, K. (Aphididæ—bug).	Same remedy as in Cow pea plant-lice (see above).	The young shoots and vines are covered with these minute insects in bad attacks.
The lablab bug	Do. ..	Do. ..	*Coptosoma cribraria*, F. (Pentatomid—bug).	The eggs and the adults can be easily collected and destroyed, the latter by handnets. Dust with B.H.C. D.O. 25.	Small active greenish insects found in thousands on the tender vines, possess the usual buggy smell. (Fig. 345, S.S.I.).

Leaf weevil ..	**Coimbatore, Ceded Districts and Northern Circars.**	**The insect defoliates the plant; sometimes seriously.**	*Episomus lacerta*, F. (Curculionid—weevil).	**Beetles to be collected by hand or by jerking over pan of water and kerosene.**	**A stout greyish weevil sometimes numerous on the field bean crop (Fig. 184, S.S.I.).**
Pod borer caterpillar.	**Coimbatore and Northern Circars.**	**Caterpillar bores into the pod and eats the seeds.**	*Adisura atkinsoni*, M. (Noctuid—moth).	**Only preventive method feasible; first attacked pods to be plucked off.**	**A cylindrical greenish caterpillar found during the cold weather, sometimes checked by parasites; more or less like gram caterpillar in appearance.**
Leaf-miner ..	**Coimbatore, Malabar and South Kanara.**	**Minute caterpillar mines into leaf-tissue and feeds from inside.**	*Cyphosticha coerulea*, Meyr. (Gracillariad-moth).	**The blistered leaves to be picked off as a preventive.**	**The affected leaves show blistered white patches through which the small pink caterpillar is visible.**
Sphinx caterpillar.	**In all tracts ..**	**The long stout caterpillar eats the leaves.**	*Acherontia styx* W. and *A. lochesis* also sometimes. (Sphingid-moths). .	**The same measures as for green gram sphinx caterpillar (see above).**	**A stout built long green caterpillar with a horn above the tail region with golden yellow bands at sides; found on gingelly and brinjal also. (Col. Pl. XXIV, S.S.I.).**
Shoot borer ..	Coimbatore.. ..	The caterpillar bores into the young distal shoots.	*Laspeyresia torodelta*, Meyr. (Eucosmid—moth).	Clip first attacked shoots as a preventive.	A minor local pest.
Stem-weevil ..	Coimbatore, Salem and North Arcot.	Larva causes galls in stems.	*Alcides pictus*, Boh (Curculionid—weevil).	Destroy first formed galls and the weevils seen on the plant.	Often a local pest in old vines.
Leaf hispid ..	Malabar and Tanjore.	Leaf-feeding	*Platypria hystrix*, Fb. (Hispidæ—beetle).	Collect beetles or dust arsenate on leaves.	A roundish small spiny insect like the hispa.
Stem boring chrysomelid.	Mysore and Coorg	Boring into stem and causing galls.	*Sagra nigrita*. Oliv. (Chrysomelid—beetle).	Remove first attacked vines as a preventive, or cut open the galls and destroy the grubs.	A shining green beetle with swollen hind legs. See Mysore Journal of the Agricultural Union 1921, p. 16.
Thrips ..	Coimbatore and Northern Circars.	Swarming inside flowers and tender shoots.	*Tæniothrips distalis*, Ky. (Thripidæ-thrips)	Spray with tobacco decoction.	The insect sometimes causes some harm; see p. 256, Thy. Mem

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			PULSES—*cont.*		
			SOYA BEAN.		
Stem borer beetle.	In tracts when this crop is grown.	Grubs bore into the stem.	*Oberia brevis*, S. (Cerambycidae).	Destroy badly infested plants.	Only a minor pest.
Groundnut Surul.	Do.	Feeds on foliage.	*Stomopteryx nerteria*, M.	See groundnut ..	
			FIBRE CROPS.		
			COTTON (*Gossypium herbaceum*).*		
Spotted boll-worms.	In all cotton areas	The caterpillars bore into top shoots of young plants and into the bolls of older ones.	*Earias fabia*, S. and *Earias insulana*, B. (Noctuid—moths).	Preventive methods alone practicable. Clip off shoots when they are attacked and pick off early attacked bolls to prevent further multiplication.	These are bigger caterpillars than the pink boll-worm and of a greyish green spotted appearance; attack young plants and also bolls. (Col. Pl. XXIII, S.S.I.).
Pink bollworm.	Do.	The caterpillar bores into the bolls and feeds on the seeds.	*Platyedra gossypiella*, S. (Gelechaid—moth.)	Preventive measures alone are practicable. Selection of healthy seeds for sowing and picking of early attacked bolls to prevent multiplication are the chief. The caterpillars are generally parasitized by wasps. Act according to Pest Act.	The small pink-coloured caterpillar is a serious pest of cotton in many cotton-growing countries of the world (Col. Pl. XLII, S.S.I.).
Stem weevil ..	Coimbatore, Madura and Ramanathapuram.	The grubs bore into the stem and cause galls.	*Pempherulus affinis*, F. (Curculionid—weevil.)	Preventive method alone practicable. Remove first attacked plants.	The insect is a small weevil and an important pest especially of cambodia cotton in and around Coimbatore (Figs. 198 and 199, S.S.I.)

Plant-lice ..	Coimbatore, Tinnevelly and Ceded Districts.	Suck the juice from the tender portions.	*Aphis gossypii*, G. (Aphidid—bug).	May be sprayed with a contact poison-like crude oil emulsion or fish oil soap.	Minute insects. Often cause appreciable injury to young cotton crop; ants visit them.
Leaf-roller ..	All over the province.	Caterpillars feed inside rolls of cotton leaves.	*Sylepta derogata*, Fb. (Pyralid—moth).	The leaf-rolls containing the caterpillars are conspicuous and can be collected and destroyed easily.	The insect is a green long caterpillar living in rolls of cotton leaf; found also on other malvaceous plants. (Col. Pl. XXXV, S.S.I.)
Dusky bug ..	In all cotton tracts.	Sucks the juice from seeds and stains the lint.	*Oxycarenus loetus*, K. (Lygæid—bug).	Prematurely opening bolls should be collected early as they harbour the pest and all *kapas* containing the pest should be kept separate and fumigated.	Small dusky brown insect found crawling in numbers in open cotton bolls like ants. (Fig. 367, S.S.I.)
Red cotton bug.	All over the province.	Punctures the boll, sucks up the juice and stains the lint.	*Dysdercus cingulatus*, F. (Pyrrhocorid—bug).	Eggs and nymphs can be handpicked and the bugs shaken over a pan of water and kerosene.	A red and black insect found in numbers on isolated plants in all stages. (Col. Pl. XLVI, S.S.I.)
Semi-looper caterpillars.	In cotton tracts ..	Leaf-eaters	*Cosmophila indica*, G., *Tarache nitidula*, F., and *Acontia graellsi*, F. (Noctuid—moths).	Rarely serious. If bad, spray with arsenates.	Figs. 257, 243, 249, S.S.I.
Cotton bud-worm.	Coimbatore, Tirunelveli and Ceded Districts.	Feeds on the top shoot in a fold.	*Phycita infusella*, M. (Pyralid—moth).	The attacked top shoots which are easily seen to be clipped.	A small green caterpillar with black head, generally found on young plants. (Col. Pl. XXXI, S.S.I.)
Boll-boring noctuids.	Coimbatore ..	Boring into bolls ..	*Helioth is obsoleta*, F. and *Rabila frontalis*, W. (Noctuid—moths).	Very rarely found ..	The first is the notorious "American cotton bollworm." Is chiefly a pest of pulses in India.
Stem-boring buprestid.	Ceded Districts ..	Larva boring into stem.	*Sphenoptera gossypii*, K. (Buprestid—beetle).	Destroy first attacked stems.	Plate VIII, S.S.I.
Shoot weevil ..	Coimbatore ..	Feeding and breeding on the shoots.	*Alcides affaber*, F. (Curculionid—weevil).	Handpick the beetles ..	Fig. 197, S.S.I.

* Detailed information on cotton pests may be found in the bulletin on cotton insects in S. India. Agr. Deptt. Bull. No. 28.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insect.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			FIBRE CROPS—*cont.*		
			COTTON (*Gassypium herbaceum*)—cont.		
Cotton blossom weevil.	Chingleput and Coimbatore.	Feeding inside the flowers.	*Amorphoidea arcuata*, M. (Curculionid—weevil).	Pick off and destroy badly infested flowers and destroy the weevils.	A very brown small weevil, not generally found as a pest. Closely allied to a very serious cotton pest in the Philippines. (*A. lata*, M.)
Scales and mealy bugs.	Coimbatore, Tirunelveli, Ceded Districts and Northern Circars.	Infest shoots and leaves and suck up plant sap.	*Saissetia nigra*, N., *Cerococcus hibisci*, Gr., *Pseudococcus virgatus*, C., *Pseudococcus corymbatus*, Gr. *Pulvinaria maxima*, Gr. (Coccidae—scales and mealy bugs).	Prune infested shoots and spray with contact insecticides.	For Figs. see S.S.I. 403 395 and Cocc. Bull. P.R. XXII and XIII.
Leaf-hopper ..	Coimbatore ..	Infest young plants in swarms and suck up plant sap causing leaf curls, bad on exotic cottons.	*Empoasca devastens*, D. (Jassid—bug).	Spray D.D.T. 0.1 per cent or dust 5 per cent.	A small very active green leaf-hopper.
Surface weevil.	Tirunelveli and Ramanathapuram.	Feeding on young plants and often causing some appreciable damage.	*Atactogaster finitimus*, F. (Curculionid—beetle).	Handpick weevils or dust arsenates on infested plants.	A stout greyish black weevil. (Fig. 191, S.S.I.)
Grasshoppers.	Coimbatore, Tirunelveli and Ramanathapuram.	Feeding on tender plants and foliage.	*Cyrtacanthacris ranacea*, Gt., *Chrotogonus saussurei*, B., *Catantops annexus*, Bol., and *Aelopus tamulus*, F. (Acridiid—grasshoppers).	Dust B.H.C. D025 ..	Figs. 424, 422, S.S.I.

Hairy caterpillars.	Coimbatore and Tirunelveli.	Feed on the foliage ..	*Euproctis fraterna*, M. (Lymantrid—moth).	Same as the one on redgram and same control measures to be adopted.	See under redgram. Rarely the red hairy caterpillar *Amsacta* and the black hairy caterpillar. *Pericallia ricini*, Fb., are also found on cotton.
Bud fly ..	Coimbatore and Mysore.	Larvæ inside buds ..	*Dasyneura gossypii*, Felt (Cecidomyid—fly).	Of very minor importance.	A closely allied fly is a pest in America; rarely seen in South India.
Flea beetles ..	Coimbatore ..	Eat the very tender seedlings.	*Monolepta signata*, 10. (Halticidae—beetle).	Net the beetles or dust with arsenate. Dust B.H.C. D O25.	A very small white spotted flea beetle. (Fig. 159, S.S.I.)
Thrips ..	Coimbatore and Bellary.	In shoots and flowers ..	*Thrips tabaci*, L. (Thripidae—thrips).	Spray tobacco decoction or dust B.H.C. D O25.	Serious on "Onions" and "Garlic." See p. 265, Thys. Mem.
Cotton mites ..	Coimbatore and Ceded districts.	Colonies of these minute creature attack plant and cause reddening of leaves, curling up, etc.	Red spider, *Eriophyes sp.*	Dust powdered sulphur ..	*Not insects.*
			GOGU (*Hibiscus cannabinus*).*		
Hairy caterpillar.	Coimbatore, South Arcot and Chingleput.	Feeds on the tender parts.	*Euproctis scintillans*, *W.* (Lymantrid—moth).	Same measures as against the Tussock caterpillar on redgram and cotton.	The caterpillar is similar to the redgram and cotton one but with a yellow stripe along the dorsal surface. (Fig. 268, S.S.I.)
Stem weevil ..	Coimbatore and South Arcot.	Grub tunnels into stem, causes galls and often kills young plant.	*Alcides affaber*, F. (Curculionid—weevil).	Only prevention by pulling out attacked plants.	See Fig. 197, S.S.I.
Flea beetle ..	Malabar, South Kanara and Tiruchirappalli.	Biting holes in tender leaves.	*Nisotra madurensis*, J. (Chrysomelid—beetle).	Collect with nets or dust with arsenates.	Fig. 160, S.S.I.
Leaf weevil ..	Coimbatore and Tirunelveli.	Feeding on leaves ..	*Dereodus mastos*, Hb. (Curculionid—weevil).	Handpick the beetles ..	The beetle is a fairly big creature and of minor importance.
Blister beetle. ..	All over the province.	Chiefly on flowers ..	*Mylabris pustulata*, Th. (Meloid—beetle).	Same insect noted above on redgram, etc., and same measures to be adopted.	*See* under redgram.

* *Note.*—The red and dusky bugs of cotton and a few cotton leaf caterpillars also attack Gogu.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insect.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			FIBRE CROPS—*cont.*		
			SUNNHEMP (*Crotalaria juncea*).		
Hairy caterpillars.	Northern Circars, Coimbatore, South Arcot and Tirunelveli.	Caterpillars feed on leaves and bore into seed capsules.	*Utetheisa pulchella*, L. (Arctiad—moth), *Argina cribraria*, C., and *A. syringa*, C. (Hypsid—moths).	Moths which are day-flying may be netted. A badly infested and valuable crop, may be sprayed with lead arsenate. In the early stages the caterpillars may be collected in trays of water and kerosene.	The first which is the commonest is a hairy caterpillar with red and orange spots. Sometimes it is serious during early summer. (Fig. 233, S.S.I.)
Pod-borer ..	Northern Circars and Coimbatore.	Caterpillar bores into pods.	*Etiella zinkenella*, Tr. (Pyralid—moth).	Remove first infested pods to check multiplication.	Fig. 305, S.S.I.
Stem-borer ..	Northern Circars ..	Caterpillar bores into stem and causes swelling at the nodes.	*Laspeyresia tricentra*, M. (Eucosmidae—moth).	Only preventive method of cutting off attacked shoots practicable.	Not a serious pest. (Col. Pl. XL, S.S.I.)
Capsid ..	Northern Circars, Coimbatore and Tirunelveli.	The small insects suck the juice from tender parts.	*Ragmus importunitas*, D. (Capsid—bug).	Use hand-nets in early stages.	Not a serious pest. Small active green insects. (Fig. 378, S.S.I.)
Flea beetle ..	Do.	Biting small holes in foliage.	*Longitarsus belgaumensis*, F. (Halticidae—beetle).	Net the beetles or spray deterrent insecticide.	A very minute active insect found often in numbers.
Leaf caterpillar.	Northern Circars, South Arcot and Coimbatore.	Leaf eater	*Amyna octo*, G. (Noctuid—moth).	Rarely a pest	A green semi-looper caterpillar.
Blue butterfly.	All over the province.	Feeding on and boring into the pods.	*Polyommatus boeticus*, L. (Lycaenid butterfly).	Collect butterfly and hand-pick the larvae.	Very rarely serious.
			OIL-SEED CROPS.		
			GINGELLY (*Sesamum indicum*).		
Leaf and pod caterpillar.	Throughout South India.	Caterpillar feeds on the leaves and bores into the shoots and pods.	*Antigastra catalaunalis*, D. (Pyralid—moth).	No effective remedy known. In the early stages handpicking will be found effective.	Often a bad pest of gingelly. (Col. Pl. XXXVII, S.S.I.).

Gingelly gall-fly.	**Coimbatore and South Arcot.**	The maggot injures the bud which forms a gall instead of a seed capsule.	*Aspondylia sesami*, F. (Cecidomyid—fly).	No effective remedy known.	The mal-formed buds contain the pink maggots inside. (Figs. 224 and 225, S.S.I.).
Sphinx caterpillar.	**Throughout South India.**	Leaf and shoot eater ..	*Acherontia styx*. W. (Sphingid—moth).	Same as found on lab-lab.	See under lab-lab.
Gingelly bugs.	**Ganjam and South Kanara.**	Suck the juice from tender parts.	*Eusarcocoris ventralis*, W. (Pentatomid—bug). *Nysius inconspicuous*, D. (Lygaeid—bug).	Use of handnet will be very effective.	Small active bugs of two or three kinds found in swarms in the early summer months. (Fig. 349, S.S.I.).
			CASTOR (*Ricinus communis*).		
Semilooper caterpillar.	In all tracts; chiefly Ceded districts.	Defoliates the plant ..	*Achoea janata*. L. (Noctuid—moth).	Handpicking of caterpillars. Spraying of lead arsenate if water is available and crop valuable. Dusting if no water available.	A major pest of castor. A smooth elongated greyish caterpillar moving in semiloops (Fig. 250, S.S.I.) called " Kondali hula " in parts of Mysore.
Tobacco caterpillar.	In all tracts ..	Do. ..	*Prodenia litura*, F. (Noctuid—moth).	Handpicking of eggmasses easy. Handpicking leaves containing hundreds of gregarious larvæ is also easy and effective.	A stout greyish brown caterpillar. It is a pest of tobacco and other plants. (Col. Pl. XIX, S.S.I.).
Seed capsule borer.	Do.	Caterpillar bores into seed capsules and leaf-stalks.	*Dichocrocis punctiferalis*, G. (Pyralid—moth).	Preventive method; first attacked shoots and top seed capsules to be clipped to prevent spread of pest.	Several seed capsules are found webbed together by the pest in an infested plant. (Col. Pl. XXXIV, S.S.I.)
Hairy and **tussock caterpillars.**	Coimbatore, South Arcot, Northern Circars and Mysore.	Defoliate the plants ..	*Orgyia postica*, W *Euproctis fraterna*, M., *Pericallia ricini*, F., *Olene mendosa*, H., and *Diacrisia obliqua*, W. (Lymantrid and Arctiad—moths).	Same remedy as for tussock caterpillar on redgram and gogu.	One or more species often appear as sporadic pests in the cold weather. (Figs. 263 and 264, S.S.I.)

I.—Insects affecting important cultivated plants in South India—*cont.*

Insect.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			OIL-SEED CROPS—*cont.*		
			CASTOR (*Ricinus communis*)—cont.		
Castor slug caterpillars.	West Coast, Coimbatore, Northern Circars and Madras.	Defoliate the plants ..	*Parasa lepida, G.*, and *Altha nivea*, W. (Limacodid—moths).	Clipping of leaves on which larvæ are found gregariously. Destruction of cocoons generally found in masses on the plant stem. Dust or spray calcium arsenate or B.H.C.	The first is an apple green slug-like creature spiny and irritating to the touch, also found on mango and palms (Figs. 283, 284 and 285, S.S.I.); the second rarely found. Noted in Mysore.
Butterfly ..	All over South India.	Leaf-eating caterpillar ..	*Ergolis merione*, Cr. (Nymphalid—butterfly).	Clipping the leaves on which the larvae feed gregariously.	Rarely a pest. A green spiny caterpillar.
Mealy wing ..	Do.	Colonies found on leaf surface sucking sap.	*Trialeurodes ricini*, M. (Aleurodidæ—bug).	Clip badly infested leaves and spray if necessary with contact insecticide.	The adults are very minute moth-like creatures.
Leaf-hopper ..	Coimbatore ..	Sometimes appear in swarms and suck sap.	*Empoasca flavescens*, F. (Jassid—bug).	Spray DDT. 0·1 per cent or dust 5 per cent.	Minute green leaf-hoppers. (Fig. 387, S.S.I.)
Flea beetle ..	Do. ..	Biting holes on foliage.	*Hermacophaga ruficollis, L.* (Halticidæ—beetle).	Collect with nets or spray deterrent.	A very minor pest. A minute beetle.
Shot-hole borer.	Mysore ..	Larvæ and adults boring into stem.	*Xyleborus fornicatus*, E. (Scolytid—beetle).	Cut and burn badly infested shoots and stems.	Sometimes found on tea. (Fig. 204, S.S.I.)
Green plant-bug.	Ceded districts and Coimbatore.	Sucking sap from tender parts.	*Nezara viridula*, L. (Pentatomid—bug).	Handpicking ..	Found on numerous other crops.
			GROUNDNUT (*Arachis hypogæa*).		
Hairy caterpillar.	Throughout the Central and Coromandel districts of the province.	Completely eating up all parts of the plant.	*Amsacta albistriga*, Moore (Arctiad—moth).	Same as found on redgram or cholam and the same remedies.	A very serious pest of groundnuts in S. India.

Surul puchi ..	South Arcot, Salem, Tiruchirappalli, Tanjore, Chingleput, etc.	The small caterpillar feeds on the foliage and does injury.	*Stomopteryx nerteria*, M. (Gelechiad—moth).	Moths come to light in numbers and light traps may be tried to minimize damage. Dust B.H.C. D 025.	A small greenish caterpillar does considerable damage to the foliage, called "*Surul*" or "*Mudu*" *puchi*. (Fig. 333, S.S.I.).
Gram caterpillar.	South Arcot and Chingleput, etc.	Feeds on the foliage ..	*Heliothis obsoleta* (Noctuid—moth).	Same insect found on bengal and redgram.	See under redgram.
Thrips ..	Ceded districts and South Arcot.	Tender shoots are sucked and dry up.	*Heliothrips indicus*, B. (Thripidæ—thrips).	Spray with tobacco decoction or dust B.H.C. D 025.	Often very bad causing "*Tamara novu*". (Thy. Mem. Fig. 1.)
Verpuchi ..	South Arcot, Chingleput and Tanjore.	The grub bores into the stem and kills the plant.	*Sphenoptera perotteti*, G. (Buprestid—beetle).	Preventive method alone practicable. Pull out attacked plants to prevent spread.	The white grub is found inside stem close to ground level. (Figs. 141 and 142, S.S.I.)
Leaf weevils ..	South Arcot and Coimbatore.	Feeding on leaves ..	*Myllocerus viridanus*, F. (Curculionid—weevil).	Collect with net	Generally a minor pest.
Semi-looper caterpillars.	South Arcot, Coimbatore and Guntur.	Do. ..	*Plusia chalcytes*, F., *Plusia signata*, F. (Noctuid—moths).	Handpick or dust arsenates	Rarely serious. (Fig. 259, S.S.I.)
Grasshopper ..	All over the province.	Feeding on and cutting young plants.	*Chrotogonus saussurei*, B. (Acridiid—grasshopper).	Dust B.H.C. D 025 ..	Attack young plants generally.
Seed-sucking bug.	Ceded districts, South Arcot and Krishna.	Sucking the freshly harvested pods in the threshing floor.	*Aphanus sordidus*, Fb. (Lygaeid—bug).	Collect with nets or cover harvested nuts to prevent attack.	Fig. 368, S.S.I.
Flower beetles.	Coimbatore and South Arcot.	Feeding on flowers and buds.	*Oxycetonia versicolor*, Fb. (Cetoniad—beetle), *Mylavris pustulata* and *Mylavris valkteata* (Cantharid—beetles).	Handpick or net the beetles; they can also be driven by smoke.	Figs. 123, 149, S.S.I.
Groundnut aphid.	In groundnut areas especially Chittoor, etc.	Colonies of these insects suck up the plant juice from the stems and leaves.	*Aphis laburni*, *Kalt.* (Aphidid—bug).	Dust B.H.C. D 025 ..	....

I.—Insects affecting important cultivated plants in South India—*cont.*

Insect.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			OIL-SEED CROPS—*cont.*		
			SAFFLOWER (*Carathmus tinctorius*).		
Leaf caterpillar.	Coimbatore, Tirunelveli, etc.	Caterpillar feeds on the foliage.	*Perigoea capensis*, G. (Noctuid—moth). Occasionally the noctuid, *Heliothis peltigera*, Sch., is also found in Coimbatore.	The leaves containing the caterpillars may be hand-picked in the early stages. May be sprayed with lead arsenate.	Smooth stout green caterpillar appears sporadically as a pest. (Fig. 239, S.S.I.).
Lace-wing bug.	Coimbatore and Tirunelveli.	....	*Monanthia globulifera*, W. (Tingidid—bug).	Rarely a pest	Fig. 371, S.S.I.
Plant lice ..	Do.	Suck up plant sap ..	*Macrosiphum solidaginis*, F. (Aphid—bug).	Spray with contact poison.	Sometimes bad.
			LINSEED (*Linum usitatissimum*).		
Leaf caterpillar.	Coimbatore ..	Caterpillars feed on the foliage.	*Grammodes stolida*, F., *Plusia orichalcea*, F. (Noctuid—moths).	Usually minor pests; spray when bad with arsenate solution.	Both are semi-loopers, the first is black and red spotted in colour. (Figs. 251, 260, S.S.I.)
			VEGETABLES.		
			BRINJAL (*Solanum melongena*).		
Fruit and shoot-borer.	In all tracts ..	Boring into the top shoots and fruits.	*Leucinodes orbonalis*, G. (Pyralid—moth).	Attacked fruits and shoots should be clipped as a preventive.	A common pest of brinjal fruits; pink caterpillar found inside fruits, attacks shoots of young plants. (Col. Pl. XXX, S.S.I.)
Stem-borer ..	Do. ..	Bores into the stem and often kills the plant.	*Euzophera perticella*, R. (Pyralid—moth).	Preventive only. Pull out and destroy first attacked plants.	Appears generally in old gardens where the plants have completed their yielding season. (Col. Pl. XXX, S.S.I.)

Epilachna beetles.	Do. ..	The beetles and the grubs scrape the green matter from the leaves.	*Epilachna* 12 *punctata*, M., *E.* 28 *punctata*, Fb. (Coccinellid—beetles).	Handpicking all stages and spraying or dusting with arsenates when bad.	Round spherical spotted beetles scraping the leaf surface. Found in all stages, also found on Cucurbitaceae. (Pl. XXX, S.S.I.)
Lace-wing bug.	All over South India.	Colonies of this small insect suck the juice from tender portions.	*Urentius echinus*, D. (Tingidid—bug).	Handpicking of leaves infested with colonies of the insect in the early stages and spraying with crude oil emulsion when badly infested.	Small insects with the wings patterned like lace, found in colonies on the backs of leaves. (Fig. 370, S.S.I.)
Brinjal mealy bug.	Chingleput and Coimbatore.	Colonies appear and suck the juice.	*Phenacoccus insolitus*, G. (Coccid—mealy bug).	Removal of the attacked plants is the best in the early stages. May be sprayed as above if many plants are attacked.	Appears generally on old plants late in the season. A bad attack on a plant appears as though the plant is whitewashed. (Pl. XXI, Fig. 3, Cocc. Bull.)
Leaf-folding caterpillars.	Madras, South Arcot and Chittoor.	Feed inside leaf folds ..	*Eublemma olivacea*, W. (Noctuid—moth). *Phycita clientella*, Z. (Pyralid—moth).	By handpicking of the folds in infested plants the pest can be easily checked.	Short stout purple brown caterpillar with yellow spots and hairs. (Fig. 241, S.S.I.).
Brinjal bud-worm.	Coimbatore and Chingleput.	The small caterpillar bores into the bud and destroys it.	*Phthorimoea blapsigona*, M. (Gelechiad—moth).	Only preventive method practicable, picking off and destroying early dropping buds.	Sometimes the insect causes appreciable damage. It is often parasitized by a wasp.
Leaf webber ..	Malabar and South Kanara.	Webbing the leaves and living gregariously inside webbed leaves feeding on the same.	*Psara bipunctalis*, Fb. (Pyralid—moth).	Clip leaves containing the larvæ.	(Fig. 317, S.S.I.)
Sphinx caterpillar.	In all tracts ..	Caterpillar defoliates the plants.	*Acherontia styx*. W. (Sphingid—moth).	Same as on lab-lab and gingelly.	See under lab-lab and gingelly.
Leaf noctuid ..	Madras, Coimbatore, Travancore and Bellary.	Leaf eater	*Plotheia nephelotis*, Meyr. (Noctuid—moth).	Handpick caterpillars or dust arsenates.	(Fig. 246, S. S.I. often found feeding gregariously).
Grey weevil ..	All over the province.	Feeding on the foliage ..	*Myllocerus subfasciatus*, G. (Curculionid—weevil).	Handpick the beetles ..	Commonly found, but rarely as a pest.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insect.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			VEGETABLES—*cont.*		
			BRINJAL (*Solanum melongena*)—cont.		
Small pentatomid.	South Kanara and Malabar.	Found in numbers on tender shoots sucking the sap.	*Coptsosoma nazirae*, A. (Pentatomid—bug).	Handpick or net the bugs.	A small dark species found on other vegetables also.
The pulse coreid.	All over the province.	Sucking sap from tender portions.	*Anoplocnemis phasiana*, F. (Coreid—bug).	Catch bugs by nets ..	A conspicuous dark brown bug with stout hind legs.
			LADY'S FINGER ("BHENDAI") (*Hibiscus esculentus*).		
		All insects found on cotton except pink bollworm attack this plant, the chief are—			
Fruit borer ..	All over the province.	Caterpillars bore into shoots and fruits.	*Earias fabia*, S. (Noctuid—moth).	*See* under cotton ..	*See* under cotton.
Stem weevil ..	Do.	The grub bores into stem and shoots.	*Alcides affaber*, F. (Curculionid—weevil).	Do. ..	Do.
Leaf-roller ..	Do.	The caterpillars fold the leaves into rolls.	*Sylepta derogata* (Pyralid—moth).	Do. ..	Do.
Semi-looper caterpillars.	In cotton tracts ..	....	*Cosmophila indica*, G., *Acontia graellsi*, F. (Noctuid—moths).	Do. ..	Do.
Leaf weevils ..	Everywhere ..	Feeding on foliage ..	*Myllocerus viridanus*, Fb. (Curculionid—weevil).	Net the weevils. Not a serious pest.	Found also on groundnut, castor, etc.—A small greenish weevil.
Leaf hopper ..	Coimbatore.. ..	Infests plants in swarms and sucks up plant sap.	*Empoasca devastens*, D. (Jassid).	Spray DDT. 0·1 per cent or dust 5 per cent.	A small and active hopper; found also on cotton.
Flea beetle ..	In tracts where this is grown.	Do.	*Podagria bouringi*, B. (Chrysomelid).	Not a serious pest ..	....
			CLUSTER BEANS (*Cyamopsis psoralioides*).		
Leaf weevils ..	Coimbatore, Bellary, South Arcot, Madurai and Chingleput.	Bores into top shoots and feeds on those portions.	*Alcides bubo*, F., *Blosyrus inaequalis*, B. (Curculionid—weevils).	Clipping off of top shoots of infested plants.	The first is a specific pest of Agathi (Fig. 196, S.S.I.) See under Agathi.

Lab-lab bug ..	Do.	Sucks up the juice from tender parts.	*Coptosoma cribraria*, F. sometimes also *C. nazirae*, A. (Pentatomid bugs).	Same as found on lab-lab ..	See under lab-lab above.
			SWEET POTATO (*Ipomoea batata*).		
Sweet potato weevil.	All over South India.	The vines are bored by the grub and damaged badly.	*Cylas formicarius*, Fb. (Curculionid—weevil).	No effective remedy known ; attacked vines and tubers to be destroyed to check spread, growing of deep-rooted varieties, and leaving the field fallow for a season or two.	An ant like blue and red weevil, a major pest of the crop, found both in the field and in the stored tubers. (Col.Pl. XII, S.S.I.)
Sphinx caterpillar.	Coimbatore and Northern Circars.	Leaf-eater	*Herse convolvuli*, L. (Sphingid—moth).	Same one noted above on green-gram.	*See* under green-gram.
Stem-borer ..	Do.	Caterpillar bores into the vines.	*Omphisa anastomosalis*, G. (Pyralid—moth).	Same remedies to be adopted as for the weevil (Cylas).	Found also on other Ipomoeaceous plants. (Fig. 316, S.S.I.)
Leaf-folder ..	Coimbatore ..	Caterpillar feeds on leaves which are rolled up.	*Brachmia effera*, Meyr. (Gelechiad—moth).	Clip folded leaves. A minor pest only.	A very slender dark caterpillar.
Leaf noctuid ..	Coimbatore, Tinnevelly.	Feeding on leaves and shoots.	*Catephia inquieta*, W. (Noctuid—moth).	Hand pick caterpillars ..	Rarely a pest.
Tortoise beetles.	Coimbatore, West Coast, Madura, Mysore, etc.	Leaf feeders. Some breed on the foliage.	*Aspidomorpha miliaris*, F., *Metriona circumdata*, H. (Cassidid—beetles).	Hand pick or net the beetles.	Yellow and green tortoise beetles. (Figs. 168, 170, S.S.I.)
Leaf hispid ..	Coimbatore ..	Feeding on leaves ..	*Oncocephala tuberculata*, Ol. (Hispid—beetle).	Of very minor importance.	A small spiny beetle.
Leaf butterfly	Coimbatore, Tinnevelly.	Do. ..	*Junonia orithyia*, L. (Nymphalid—butterfly).	Catch butterfly with net and handpick larvae.	Rarely a pest.
Hairy caterpillar.	Malabar	Feeding on leaves ; sometimes bad.	*Diacrisia obliqua*, Wlk. (Arctiad—moth).	Handpick leaves on which larvae feed in numbers.	Sometimes a sporadic pest.
Leaf syntomid	Travancore ..	Larva feeding on leaves.	*Euchromia polymena*, L. (Syntomid—moth).	Handpick the larvae ..	Of very minor importance ; a black moth with orange an red markings.

I.—Insects affecting important cultivated plants in South India—cont.

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			VEGETABLES—*cont.*		
			POTATO (*Solanum tuberosum*).		
The tuber-borer.	Nilgiris, Mysore ..	The caterpillar burrows into the tuber and damages it badly in stored tubers. ..	*Phthorimoea operculella*, Z. (Gelechiad—moth).	It is more a pest of the stored tubers. Only prevention; fumigate or store the tubers in sand. In the case of plants pull out and destroy first attacked plants.	Found both in the field and in the stored tubers. A serious pest sometimes. (Col. Pl. XLIV, S.S.I.)
Leaf-caterpillar.	Shevaroys and Nilgiris.	Defoliates the plant and cuts seedlings.	*Euxoa segetum*, S. (Noctuid—moth).	Handpicking of caterpillars in early stages and trapping by poisoned baits when badly infested.	A stout dark brown caterpillar, generally found as a pest only in the hills and only serious at times. (Fig. 237, S.S.I.)
Epilachna beetle. ..	Mysore, Nilgiris and Coimbatore.	Defoliates the plants ..	*Epilachna 12 punctata, E. 28 punctata* (Coccinellid beetles).	See under brinjal ..	Brownish spotted beetles.
Green plant bug.	Shevaroys, Mysore	Sucks up sap from tender tissues.	*Nezara viridula*, *L.* (Pentatomid-bug).	Handpick the bugs, eggs and nymphs.	*See* under cumbu and castor.
Wire-worm ..	Nilgiris	Larva bores into the underground tubers.	*Drasterius sp.* (Elaterid—beetle.)	Irrigate water mixed with contact insecticide.	Sometimes serious.
Ground beetles.	Nilgiris and Mysore.	Nibbling roots	*Gonocephalum hoffmanseggi*, St. also *Opatrum sp.* (Tenebrionid—beetles).	Collect beetles	(Fig. 143, S.S.I.)
Leaf-beetle ..	Nilgiris	Cutting holes in foliage.	*Chalaenosoma metallicum*, F. (Halticid—beetle).	Net beetles or dust the plants with arsenate.	Not a serious pest.
Leaf-hopper ..	Do.	See Cotton	*Empoasca devastens*, D. (Jassid).	Spray DDT 0·1 per cent or dust 5 per cent.	*See* Cotton.

			MORINGA (*Moringa pterygosperma*).			
Hairy caterpillar.	**Throughout India.**	**South**	**Defoliates the plants ..**	*Eupterote mollifera* Wlk. (Eupterotid—moth). *Pericallia ricini*, F. (Arctiad—moth).	Burning the swarms of caterpillars with a lighted torch or spray them with any contact insecticide.	The caterpillars of Eupterote are often found in thousands resting together on the plant stem; they are hairy and irritating. (Fig. 275, S.S.I.)
Leaf-caterpillar.	**Coimbatore, Districts Chingleput.**	**Ceded and**	Folds the leaf and feeds from inside.	*Noorda blitealis*, W. (Pyralid—moth). *Actias selene*, H. is also sometimes found.	Handpicking the leaf folds is an easy method for this insect.	Not a very common pest; small greenish caterpillar of a blackish moth. (Fig. 318, S.S.I.)
Stem-borer ..	Coimbatore	..	Larva bores into stem ..	*Coptops aedificator*, F. (Cerambycid—beetle).	Cutting off first attacked stems and killing beetles when found; using borer solution if necessary.	Only occasionally found.
			PUMPKINS, CUCUMBERS, GOURDS, ETC. (*Cucurbitaceae*).			
			(The insects affecting the different species of cucurbits are more or less the same.)			
Pumpkin caterpillar.	Throughout India.	South	Caterpillar feeds on the foliage.	*Margaronia indica*, S. (Pyralid—moth).	May be sprayed or dusted with a stomach poison in bad cases; otherwise hand-picking of leaf-fold is easy and effective.	A bright green elongated caterpillar with a double white stripe on the body. (Fig. 312, S.S.I.)
Pumpkin leaf-beetles.	Do		Beetles feed on the foliage.	Aulacophora—three species, *A. foveicollis*, Red, A. *atripennis*, Blue, and *A. stevensi*, Grey (Chrysomelid—beetles).	Collecting by nets. Dusting the plants with a stomach poison in bad cases.	These are active insects and sometimes cause appreciable damage to leaves of gourds, melons and pumpkins. (Figs. 161, 162 and 163, S.S.I.)
Epilachna beetle.	Do.		Beetles and grubs feed on foliage.	*Epilachna 12 punctata*, and *E. 28—punctata* (Coccinellid-beetles).	Same as that found on brinjal.	*See* under brinjal above.
Fruit flies ..	Do.		Maggots bore into the fruit pulp and damage the same.	Important species found are *Chaetodacus caudata*, B., *C. cucurbitae*, Coq and *Dacus brevistylus*, B. (melon fly.) (Trypetidae—fruit flies).	Prevention. Destruction of badly infested fruits. Spraying of plants with a sweetened poison to kill the flies may also be tried in bad cases.	Often bad on bitter gourds and melons. Found also in mango and other fruits. (Col. Pl. XVI, S.S.I.)

I.—Insects affecting important cultivated plants in South India—cont.

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			VEGETABLES—*cont.*		
		PUMPKINS, CUCUMBERS,	GOURDS, ETC. (*Cucurbitaceae*)—cont.		
Snake-gourd semi-looper.	Throughout South India.	Feed on leaves; young vines often suffer badly.	*Plusia peponis*, F. (Noctuid—moth).	The leaf folds containing the caterpillars and pupae are conspicuous and can be easily hand-picked.	A pale green semi-looper caterpillar, more or less confined to the snake gourd plant, rarely found on other cucurbits.
Pumpkin stem-borer.	Northern Circars and Coimbatore.	Grub bores into vines of the plants.	*Apomecyna pertigera* Th. (Cerambycid—beetle).	Preventive method only. Destruction of first attacked vines; also the destruction of adult beetle when found in the field.	Chiefly noted in the Northern Circars on the cucurbit called "*Dondekaya*" in Telugu. (Col. Pl. XI, S.S.I.)
Plant lice ..	All over South India.	Colonies suck plant sap.	*Aphis malvae*, K. (Aphidid-bug).	In bad cases spray contact poison.	Predators often check it.
Bottle gourd plume moth.	Throughout South India.	The slender spiny caterpillar is a leaf eater.	*Sphenarches caffer*, Z. (Pterophorid—moth).	Clipping off infestad leaves is an effective method.	Not a serious pest generally, appearance similar to red-gram plume moth. (Fig. 320, S.S.I.)
Snake-gourd weevil.	Tanjore	Attacking shoots and leaves.	*Baris sp.* (Curculionid—beetle).	Collect beetles	Minute black insect, some times causing appreciable damage.
Melon gourd weevil.	Ceded districts ..	Larva and adult found boring into fruits.	*Acythopius citrulli*, M. (Curculionid—beetle).	Destroy badly infested fruits and weevils when found.	A medium-sized black weevil.
Plant bugs ..	Throughout South India.	The active bugs suck the juice from tender portions; sometimes found in swarms.	*Aspongopus janus*, F. and *A. brunneus*, Th. (Pentatomid—bugs).	Collect bugs with net ..	A reddish or greyish brown active insect with a bad smell found on pumpkins generally.
Bitter gourd gall-fly.	Coimbatore ..	Larva causing elongated galls in tender vines.	*Lasioptera falcata*, Felt. (Cecidomyiad—fly).	Clip off badly galled vines.	Not a serious pest.

		AMARANTHUS (*Amaranthus spp.*).			
Amaranthus weevil. ..	All over South India.	The grub bores into the shoots, tender portions of the stem and often kills the shoot.	*Lixus brachyrhinus*, B. (Curculionid—beetle).	Being a borer only preventives possible. Cutting off of attacked shoots and killing of the bettle when found on the plants.	Found on wild varieties of amaranthus also (Fig. 189, S.S.I.)
Leaf caterpillar. ..	Do.	Caterpillar feeds on foliage.	*Hymenia fascialis*, C. (Pyralid—moth).	Handpicking of early attacked leaves. Netting and destruction of moth which is found in the fields.	Not a bad pest generally. Very common on grasses and other low—growing shrubs. (Fig. 307, S.S.I.)
		CHILLIES (*Capsicum spp.*).			
Chillies thrips.	All over South India, especially in the Guntur district.	These minute insects suck the juice from shoots and make the tender leaves curl and fade.	*Scirtothrips dorsalis*, Hood. (Thripidæ—thrips).	Spraying with tobacco washes and dust with tobacco even in the nurseries to prevent multiplication or dust with BHC D025.	Often a serious pest and found in company with plant lice (Thys. Mem. p. 251).
Leaf caterpillar.	Northern Circars and Coimbatore.	Feeds on the leaves ..	*Laphygma exigua*, H. (Noctuid—moth).	Net the caterpillars if in numbers; dust arsenates if serious.	Occasional pest.
Chafer beetle ..	Guntur	Larvae attack roots of young plants.	*Cockchafer* (Melolonthid—beetle), not named.	Flood soil with insecticide mixed with water.	A local pest.
Stem-borer ..	Coimbatore and Northern Circars.	Caterpillar bores into stem.	*Euzophera perticella*, R. (Pyralid—moth).	See under brinjal	Not very common on chillies.
		ELEPHANT-FOOT YAM (*Typhonium sp.*).			
Leaf beetle ..	Malabar and Godavari.	Larvae and adults feed on the leaves, the former gregariously.	*Galerucida bicolor*, H. (Chrysomelid—beetle).	Collect leaves containing larvae and net beetles.	Local pest; at times serious.
Sphinx caterpillar.	Coimbatore ..	Feeding on foliage ..	*Hippotion celerio*, L. (Sphingid—moth).	The stout caterpillars can be easily handpicked.	Found on grape vine also.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			VEGETABLES—*cont.*		
			COLOCASIA (*Colocasia spp.*).		
White spotted beetle.	Coimbatore and Northern Circars.	The beetle bites holes on the foliage and feeds on the same.	*Monolepta signata*, Ol. (Chrysomelid—beetle).	Netting the beetles will be found effective.	Fig. 159, S.S.I.
Tobacco caterpillar.	Tanjore, Coimbatore and Malabar.	Feeds on the leaves ..	*Prodenia litura*, F. (Noctuid—moth).	Same one found on castor.	*See* under castor, tobacco, etc.
Striped wing thrips.	Northern Circars and Tanjore.	Numerous adults and larvae suck up sap from foliage.	*Heleothrips indicus*, B. (Thripidæ—thrips).	In bad cases spray with tobacco decoction.	A minor pest only; sometimes found on ground-nuts.
Sphinx caterpillar.	Coimbatore, Malabar, Tirunelveli and Tanjore.	Feeding on leaves ..	*Hippotion oldenlandiae*, F. (Sphingid—moth).	Caterpillars can be easily handpicked.	The adult is a stout greyish brown moth.
			CURRY-LEAF PLANT (*Murrayia koenigi*).		
Citrus butterfly.	All over South India.	Caterpillar feeds on leaves.	*Papilio demoleus*, L. (Papilionid—butterfly.)	Eggs, caterpillars and pupae which are conspicuous on the plants can be collected and destroyed. The butterfly which is easily recognized can also be netted.	*See* under citrus plants on which the insect is a serious pest sometimes.
Shoot bug ..	Coimbatore and Malabar.	Minute insects infest tender shoots and leaves and suck the juice.	*Diaphorina citri*, Kuw. (Psyllid—bug).	Clipping of attacked shoots and spraying of tobacco decoction.	Very small insects sometimes do appreciable damage.
			ONIONS AND GARLIC.		
Thrips ..	Coimbatore, Mysore, Ceded Districts, and South Arcot.	Covering foliage and making the plants blighted; often serious.	*Thrips tabaci*, L., *Heliothrips indicus*, B. (Thripidæ—thrips).	Spray with tobacco washes in the early stages or spray BHC 0·1 per cent or dust BHC D025.	*Thrips tabaci* is a minute yellowish insect found in thousands in bad attacks; the other is not so commonly found. (Thys. Mem., p. 265.)

Leaf caterpillar.	Coimbatore, Ceded Districts, and Northern Circars.	Feeding on the foliage ..	*Laphygma exigua*, H. (Noctuid—moth).	See under chillies	Occasionally serious.
		TOMATO (*Lycopersicum esculentum*).			
Tobacco caterpillar.	All over the province.	Caterpillar feeds on leaves and bores into fruits.	*Prodenia litura*, F. (Noctuid—moth).	Same as on castor. Attacked fruits to be plucked and the worms handpicked. (See under castor).	Sometimes found together with the gram caterpillar (*Heliothis*) boring into tomato fruits.
Epilachna beetles.	Do.	Grubs and beetles feed on the foliage.	*Epilachna* 12 *punctata*, M., *E.* 28 *punctata*, F. (Coccinellid—beetles).	Same as on brinjal ..	Sometimes bad on tomato.
Mealy bugs ..	Do.	Millions of these small creatures cover the plants and suck the juice.	*Pseudococcus virgatus*, F. (Coccid—mealy bug).	Removal of first attacked plants or spraying with crude oil or fish oil emulsion.	Whole plants are often covered with colonies of these white cottony insects. (Cocc. Bull. Pl. XXI-2).
Eel worms ..	Coimbatore ..	Attacking roots and killing plants.	*Heterodera radicicola* (Nematode—Eel worms).	Destroy first attacked plants and try strong manures.	*Not an insect.*
		CABBAGE, CAULIFLOWER, RADISH, MUSTARD, ETC (*Cruciferae*).			
		(The insects affecting these Cruciferae are more or less similar).			
Cabbage borer	On the hills, Coimbatore, and Mysore.	Caterpillar bores into the cabbage and also into the stem.	*Hellula undalis*, Fb. (Pyralid—moth).	Being a borer preventive methods more effective. Destroying or plucking off early attacked plants.	A greyish brown caterpillar. (Fig. 314 S.S.I.)
Mustard leaf-webber.	Coimbatore, Mysore, Ceded Districts, and Godavari.	Caterpillar feeds on leaf and webs together the foliage.	*Crocidolomia binotalis*, Z. (Pyralid—moth).	Prevention by handpicking or destroying first attacked plants in early stages or use naphthalene emulsion.	Elongated greenish caterpillar found often bad on mustard and radish (Fig. 313, S.S.I.).
Diamond back moth.	On the hills and elevated places generally.	The slender caterpillar feeds on cabbage, cauliflower, etc.	*Plutella maculipennis*, C. (Plutellid—moth).	Handpicking and destruction of attacked plants in early stages. Naphthalene emulsion may be employed in bad cases.	The caterpillar is a very slender pale green one and the moth has a diamond mark on its wings ; hence the name. (Fig. 340, S.S.I.).

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			VEGETABLES—*cont.*		
		CABBAGE, CAULIFLOWER, RADISH, MUSTARD, ETC. (*Cruciferae*)—cont.			
		(The insects affecting these Cruciferae are more or less similar)—*cont.*			
Flea beetle ..	Coimbatore ..	Cuts holes on the foliage.	*Phyllotreta downsei*, B. (Halticid—beetle).	Net the beetles or dust powdered tobacco on plants.	Minute bluish black beetle.
Mustard saw-fly.	On the hills, Godavari delta, Mysore, Bellary, and Coimbatore during the cold weather.	The black worm-like grub is a defoliator on all Cruciferae.	*Athalia proxima*, Kl. (Tenthredinidae—saw-fly.)	Same remedy as for the diamond-back moth, but handpicking is easier in this case.	This is the only wasp pest of any cultivated crop in South India. (Pl. II, Figs. 12 and 13, S.S.I.)
Cutworms ..	Hills, Mysore ..	Feeding on foliage ..	*Euxoa segetum*, Sch., Other cutworms such as *Agrotis Cinigrum*, L., are also found (Noctuid—moths).	Trap them with baits ..	Sometimes bad on the hills.
Cabbage bugs.	Throughout the province.	Suck up nutrition from tender parts of plants.	*Bagrada picta*, F. (Pentatomid—bug).	By handpicking and netting this pest can be easily checked.	Flattish red and black-spotted bug. (Col. Pl. II. Fig. 10, S.S.I.)
Thrips ..	Ceded Districts and Coimbatore.	In colonies ; sucks up the juice affects the growth of the plant badly.	*Thrips tabaci*, L. (Thripidae—thrips).	See under onion	Not so serious as on onions.
				Note.—Dusting with BHC D025 will give relief in the case of all the above pests of cruciferous crops.	
			FRUIT PLANTS.		
			MANGO (*Mangifera indica*).		
Mango hopper.	Northern Circars, Salem, Mysore, Chittoor, etc.	The insects suck up the juice from the flower heads and make them drop.	*Idiocerus niveosparsus*, L., is the commonest; other two sometimes found are *I. clypealis*, L., and *I. atkinsoni*, L. (Jassid—bugs).	Spraying infested trees with Fish oil soap or crude oil emulsion three or four times at intervals of a week or ten days during the flowering season. Treatment with sulphur dust found effective.	Number of these small active insects attack mango flower shoots during the cold weather and do considerable damage in certain years ; called "*Honey dew*" disease of mango (Fig. 384, S.S.I.)

Mango stem-borer.	All over South India.	The stout grub bores into the stem and often kills branches and stem.	*Batocera rubus*, L. (Cerambycid—beetle). Sometimes *Arbela tetronis*, M. (Zeuzerid—moth) also attacks mango stem.	Remove the grubs with a hooked wire ; if impossible syringe into the bore a mixture of chloroform and creosote ; this will kill the borer inside and will not affect the tree.	The beetle and grub are large-sized creatures, the former has long feelers and a hard body (Fig. 179, S.S.I.)
Fruit flies ..	Do.	The white wriggling maggots burrow into the fruit pulp and spoil the fruits.	*Chaetodacus incisus*, W. and *C. ferrugineus*, Fb., appear to be the commonest of the species found in S. India.	Destroy infested and fallen fruits and spray foliage with sweetened poison to kill flies.	A serious pest of mango fruits almost every year. (Pl. XVI, S.S.I.)
Leaf caterpillars.	In different parts of the province.	Feeding on leaves exposed, rolling leaves from inside or webbing of leaves and shoots or by mining into leaf tissue and shoots.	Numerous species have been noted. the following are the chief.—Slug caterpillar, *Parasa lepida*, C. (Limacodid—moth). Tussock caterpillar, *Euproctis scintillans*. W (Lymantrid—moth), Shoot webber, *Orthaga exvinacea*, M. (Noctuid—moth), Shoot webber and borer, *Chlumetia transversa* (Pyralid—moth), Leaf eater, *Bombotelia jocosatrix*, G. (Noctuid—moth), Leaf miner, *Acrocercops syngramma*, M. (Gracillarid—moth), Leaf eater, *Euthalia garuda*, M. (Nymphalid—butterfly).	Caterpillars may be hand-picked, the webbings and bored shoots clipped and in bad cases a stomach insecticide may be used.	Some of these only occasionally become serious and can be easily checked.
Leaf weevils ..	Northern Circars, Chittoor, Chingleput, South Kanara, etc.	Different kinds feeding on the foliage either openly or in folds or the grubs of some mine into leaves.	*Apoderus tranquebaricus*, F. (leaf-twister), *Eugnamptus marginatus* (leaf-tip cutter). *Rhynchaenus mangiferae* (leaf-miner) (all Curculionid beetles).	Same remedy as for leaf caterpillars. The beetles may be jerked and destroyed over a pan of water and kerosene or leaf folds collected and destroyed.	Harmful to tender foliage. They are rarely serious. (Figs. 193, 186 and 192, S.S.I.)
Nut weevil ..	Salem, Coimbatore, Bangalore and Chittoor.	The weevil developing inside the nuts and sometimes damaging pulp.	*Cryptorhynchus mangiferae*, Fb. (Curculionid—beetle).	Destruction of beetles when found and proper disposal of mango nuts after use of fruit.	Affects some special varieties of fruits badly. (Fig. 200, S.S.I.)

I.—Insects affecting important cultivated plants in South India.—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			FRUIT PLANTS—*cont.*		
			MANGO (*Mangifera indica*)—cont.		
Mango jewel beetle.	Visakhapatnam and Coorg.	Larva sometimes bores into stem.	*Belinota prasina*, Th. (Buprestid-beetle).	Same as for the other stem-borer on mango. (See above.)	A shining bluish black beetle. Not commonly seen.
Scales and mealy bugs.	Coimbatore, Visakhapatnam, Bangalore, Salem and Chittoor.	Colonies of these cover shoots, leaves and fruits and suck up sap.	Many species are found, the following being important.—*Chionoaspis vitis*, Gr. *Phenacoccus mangiferae*, *P. iceryoides*, Gr. *Pulvinaria psidii*, M., *Lecanium adersi*, N. (Coccid-scales and mealy bugs).	Prune badly infested branches and spray with contact insecticides.	The mealy bugs sometimes cause serious damage. In many cases of injury by these insects ants are found visiting the infested leaves. For figures see Cocc. Bull. Pl. VI (1), Pl. XXIV, Pl. XXV and Pl. XII (1).
Shoot bugs ..	South Kanara and Malabar.	Numbers settle on tender shoots and suck up sap.	*Coptosoma nazirae*, A. (Pentatomid-bug).	Collect the bugs by hand or nets.	A minor pest on very young plants.
Red ant ..	West Coast tracts chiefly.	Builds nests on mango and other fruit trees and prevents men going up the trees.	*Oecophylla smaragdina* Fb. (Formicid-ant).	Burn nests with torches. Dust with BHC D025.	Fig. 114, S.S.I.
			CITRUS (*Oranges, Lemons, Pomelos, etc.*)		
Citrus better-fly.	All over South India	Thecaterpillar defoliates the plants often seriously.	*Papilio demoleus*, L. Another closely allied species, *P. polytes*, L. is also found with this butterfly.	Eggs, larvæ and pupæ are very conspicious on plants and can be easily hand-picked; in bad cases infested plants may be sprayed with stomach poison. The butterfly can also be netted.	*See* under "Curry-leaf plant" above. (Col. Pl. XXV, S.S.I.).

The fruit moth.	Northern Circars and Ceded Districts.	The moth pierces the fruits and makes them rot and drop down.	*Ophideres fullonica*, L. Allied species noted as a similar pest is *O. materna*, L. (Noctuid—moths).	Moths may be caught by sugary traps. Valuable fruits may be protected by cloth or wicker covering to keep off moths. Deterrents may also be sprayed to keep off moths from fruits.	Only example of the adult insect doing damage among the Lepidoptera; often a very serious pest.
Shoot and stem-borer.	Ceded Districts and Northern Circars.	Caterpillar bores into top shoots and stems showing galleries outside.	*Arbela tetraonis*, M. (Arbelid—moth).	Clipping attacked shoots and syringing as in mango stem-borer above.	Found as a bark or shoot-borer on different trees; the tubular gallery is seen outside on the tree stem.
Fruit flies ..	Nilgiris	Larvæ breed inside fruits.	*Chaetodacus spp.* (Trypetid—fly).	Trap flies by bait and destroy first-attacked fruits.	Fruit flies on citrus are rare in South India so far.
Stem borer beetle.	Coorg, Mysore and Salem.	The beetle grub has the same habit as the mango stem borer.	*Chloridolum alcmene*, T. Sometimes also another very similar beetle. *Chelidonium cinctum*, G. (Cerambycid-beetles).	Same remedies to be employed as in the case of the mango stem-borer above.	The beetles are shining blue in colour, with long feelers. (Fig. 177, S
Citrus leaf miner.	All over South India.	The small caterpillar mines into the leaf-tissue and makes the leaf curl and fade.	*Phyllocnistis citrella*, S. (Lyonetiad—moth).	Picking off early attacked leaves; difficult to check when badly infested.	Sometimes all the leaves of the plant are found mined and curled up. (Fig. 341, S.S.I)
Psyllid ..	Coimbatore ..	Swarm on the tender shoots and suck sap.	*Diaphorina citri*, K. (Psyllid—bug).	Collect adults and spray with contact insecticide.	Feeds also on Murrayia plant.
Plant lice ..	Coimbatore and Northern Circars.	Colonies of these dark insects cover young shoots and suck the juice.	*Aphis tavaresi*, D.G. (Aphidid—bug).	Clipping badly infested shoots and spraying with Crude oil emulsion or fish oil soap.	Sometimes a bad pest found covering all the tender shoots of a plant.
Shoot cricket.	Mysore	Cutting tender shoots ..	*Brachytrypes portentosus*, L. (Gryllid—cricket).	Trap them with baits and catch when seen.	(Fig. 430, S.S.I.) Known to injure Casuarina seedlings in Nellore.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			FRUIT PLANTS—*cont.*		
			CITRUS (*Oranges, Lemons, Pomelos, etc.*)—cont.		
Shoot butterfly.	Northern Circars and Coimbatore.	Small caterpillar found on tender shoots and leaves.	*Chilades laius*, C. (Lycænid—butterfly).	Clip infested leaves and collect butterflies with net.	A minor pest.
Orange thrips.	Mysore and Nilgiris.	On one occasion found covering and discolouring leaves and fruits badly in Mysore.	*Thrips sp.* One sp. found in small numbers in orange flowers on the Nilgiris is described as *Thrips nilgiriensis*, R.	Spray tobacco decoction early in the season.	
Leaf folder ..	In all tracts ..	Caterpillar folds the tender leaves.	*Tonica zizyphi*, *St.* (Oecophorid—moth).	Clip the folds	A minor pest. (Fig. 335 S.S.I.)
Mealy wings ..	Nellore, Northern Circars and Coimbatore.	All stages of the insect infest tender parts and suck sap.	*Aleurocanthus spiniferus*, Qt. *Dialeurodes citri*, A., is also found occasionally. (Aleurodid-bugs).	Clip badly infested parts and spray contact insecticide.	Occasionally serious.
Shoot and fruit-sucking bugs.	Kurnool, Northern Circars and on the hills.	Sucking sap from tender shoots and fruits; the latter sometimes badly damaged.	*Vitellus orientalis*, D. *Cappæa taprobanensis*, D. (Pentatomid-bugs) and *Dasynus antennatus*, Vb. (Coreid-bug).	Collect bugs by hand or nets.	Local minor pests.
Citrus mite ..	Northern Circars and Coimbatore.	Covering leaves and sucking sap.	*Tetranychus hindustanicus*, H.	Spray or dust sulphur ..	*Not an insect.*

Scales and mealy bugs.	Coimbatore, Northern Circars, Nilgiris, etc.	Colonies cover the tender parts and suck sap.	Scales include chiefly: *Icerya purchasi*, M., *Lepidosaphes becki*, N., *Lecanium viridis*, G., *Pulvinaria psidii*, G., *Saissetia hemisphaericum*, T., *Pseudococcus corymbatus*, Gr. and *Parlatoria zizyphus*, L. (Coccid—bugs).	On the Nilgiris .. .. (*Icerya purchasi*, *Lepidosaphes becki*, *Lecanium viridis*) Everywhere especially on the hills. (*Pulvinaria psidii* … *Parlatoria zizyphus*) *Control*:—Prune badly infected shoots and spray contact insecticides.	Some of these cause serious damage at times For fig. see Cocc. Bull. Pl. XXXI, XVII, XII and XXII.
			The fluted scale *Icerya purchari*, M. is now kept under check in the Nilgiris and Kodaikanal Hills by means of the biological m thod cf control. The specific predatory beetle of this pest *Rodolia cardinalis* M., both adults and grubs are reared by the millions and released in the field in the scale-infested areas.		

GUAVA (*Psidium guava*).

Mealy scale ..	All over South India.	Colonies of the bug cover the leaves, suck the juice, and cover leaves with a sickly mould.	*Pulvinaria psidii*, Gr. (Coccid—mealy bug).	Clip badly infested leaves and spray Crude oil or Fish oil emulsion.	*See* also under mango and citrus for this insect. See Cocc. Bull. Pl. XII.
Fruit fly ..	All over South India.	Maggots bore into and damage fruits.	Two or three species chiefly *Chaetodacus incisus*, W. (*Trypetid*—fly).	As under mango.	
Fruit moth ..	Northern Circars ..	Moths suck the fruits ..	*Ophideres fullonica*, L. (Noctuid—moth).	As under citrus	*See* under citrus.
Scales.	**Coimbatore and Malabar.**	Cover tender parts and fruits.	*Saissetia hemisphaerica*, T., *Lecanium viride*, Gr. (Coccid—scales).	As for mealy scale ..	Cocc. Bull., Fig. 5 and Pl. XVII, Fig. 2.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			FRUIT PLANTS—*cont.*		
			POMEGRANATE (*Punica granatum*).		
Fruit borer butterfly.	All over South India.	The caterpillar bores into the fruits and damages them.	*Virachola isocrates*, F. (Lycaenid—butterfly).	Damaged fruits to be picked off and good-fruits covered with loose muslin or paper bags to prevent attack by the butterfly. The butterfly can also be netted.	The caterpillar is a short dirty brown creature. Attacked fruits show small holes. (Fig. 289, S.S.I.)
Castor seed borer.	Coimbatore.. ..	Caterpillar bores into fruit.	*Dichocrocis punctiferalis*, G. (Pyralid—moth).	See under castor	Very rarely found serious.
Leaf caterpillars.	Northern Circars, Coimbatore, etc.	Feed on the foliage ..	*Parasa lepida*, Cr. (Limacodid—moth), *Euproctis fraterna*, M. (Lymantrid—moth), *Achoea janata*, L. (Noctuid—moth).	Hand picking in early stages and spraying with stomach poison in bad attacks.	See under castor for information regarding these insects.
Fruit bug ..	Kurnool	Sucking fruits	*Jurtina indica*, D. (Pentatomid—bug).	Collect bugs by nets ..	A minor pest.
Mealy wing ..	Coimbatore and Mysore.	All stages suck sap from tender parts.	*Siphonimus finitimus*, Silv. (Aleurodid—bug).	Spray with contact insecticide when bad.	Do.
Mealy bug ..	Coimbatore.. ..	Covering fruits in numbers and sucking it.	*Pseudococcus lilacinus*, Cock. (Coccid—mealy bug).	Do.	Sometimes bad (Pl. XXIII, Fig. 1—Cocc. Bull.)
Scale	Do.	On stem and shoots ..	*Aspidoproctus cinerea*, G.	Handpick scales and spray contact insecticide.	The insect is a stout giant scale and easily seen. (Cocc. Bull. Pl. XXIX, fig. 2.)
			GRAPE (*Vitis vinifera*).		
Flea beetle ..	Mysore, Salem, Coimbatore and Northern Circars.	The small beetle bites holes into tender leaves; often the foliage is badly eaten up.	*Scelodonta strigicollis*, M. (Chrysomelid—beetle).	Spray DDT or BHC 0·%.	A small copper brown active beetle. (Fig. 158, S.S.I.)

Chafer beetles.	Coimbatore, Madras, Mysore and South Kanara.	The beetles come out at night and defoliate the vines often seriously.	Two species chiefly noted are—*Adoretus lasiopygus*, B., and *A. bengalensis*, B. (Rutelid—beetles).	Set up light traps and spray or dust with stomach poison as above.	These small brown beetles often come to light at dusk. (Fig. 127, S.S.I.)
Leaf sphingid.	Coimbatore and Mysore.	Feeding on leaves ..	*Hippotion celerio*, L. (Sphingid-moth).	Handpicking of caterpillars and eggs easy.	Rarely serious.
Leaf roller ..	Coimbatore, Mysore and South Kanara.	Rolls leaves and feeds on the same.	*Sylepta lunalis*, G. (Pyralid—moth).	Handpicking of rolls ..	Occasionally bad.
Leaf miner ..	Coimbatore, Madras, Mysore and South Kanara.	Mines in the leaf ..	*Phyllocnistis toparcha*, M. (Lyonetiad—moth).	Clip badly infested leaves.	Do.
Grape thrips ..	Coimbatore, Madurai, Travancore, Mysore, Northern Circars and Nilgiris.	All stages cover tender foliage and suck sap; sometimes serious.	*Rhipiphorothrips cruentatus*, H. (Thripid—thrips).	Clip badly infested leaves and spray tobacco decoction.	Found on roses also (Fig. 16, Thy. Mem.)
Scales ..	Coimbatore, Mysore and Salem.	Colonies found sucking juice from shoots and leaves.	*Aspidiotus lataniae*, Sign, *Aspidiotus cydoniae*, C., *Lecanium longulum*, D., *Pulvinaria maxima*, Gr. (Coccid—bugs).	Do.	The leaves and vines are sometimes badly covered with one or more of these scales. (Cocc. Bull. Pl. VIII. fig. 1 and Pl. XIII.)
Vine girdler ..	Mysore and Coimbatore.	Rings the stems and often kills them.	*Sthenias grisator*, Fb. (Cerambycid—beetle).	Not easy to check. Catch beetles when found.	(Fig. 182, S.S.I.)
Ground beetle.	Mysore and Coimbatore.	Found on tender plants.	*Gonocephalum depressum*, Th. (Tenebrionid—beetle).	See under potato	*See* under potato.
Termites ..	Do.	Found on roots and plant cuttings.	*Odontotermes obesus*, R. (Termitid—white ant).	See under sugarcane ..	Sometimes serious.

MELONS.

(Chief insects affecting melons are those found on other cucurbitaceae.)

FIG. (*Ficus spp.* INCLUDING BANYAN, PEEPUL, ETC.)

Stem-borer beetle.	Northern Circars and Coimbatore.	The grub burrows into the stem and often kills the shoot.	*Olenecamptus biolobus*, F. (Cerambycid—beetle).	Same remedy as in the case of the mango stem borer beetle.	The beetle is a slender pale white insect with very long feelers.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insect.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			FRUIT PLANTS—*cont.*		
			FIG.		
Leaf caterpillars.	Coimbatore, Bangalore and Tiruchirappalli.	Feeding on leaves often defoliating whole plant.	*Ocinara varians*, W. (Bombycid—moth), *Perina nuda*, Fb. (Lymantrid—moth), *Hypsa ficus*, Fb. (Hypsid—moth), *Phycodes radicata*, O. (Glyphipterygid—moth), *Margaronia stolalis*, G. (Pyralid—moths) and Glyphodes 2 or 3 spp. and *Plotheia celtis*, M. (Noctuid—moth).	Spray with arsenates in bad attacks of these larvae.	Occasionally serious. A. very minor pest.
Scale insects and mealy bugs.	Northern Circars, Coimbatore and Mysore.	Colonies sometimes cover shoots and fruits and suck up the juice.	*Saissetia oleae*, B. *Aspidiotus cydoniae*, Comst. *Pseudococcus lilacinus*, and *Lecanium ramakrishnae*, G. Cock. (Coccid—scales and mealy bugs).	Spraying with a contact poison when serious.	See bulletin on Coccidae, Pl. XIV, (3), (Pl. VIII, Fig. 1), Pl. XXIII (1), and Pl. XVI (1).
Thrips ..	Northern Circars and Malabar.	Colonies crowd on tender parts and make leaves, curl.	*Gigantothrips elegans*, Z. (Phloeothripid—thrips).	Clip badly infested shoots and leaves.	A large-sized species of Thrips found on most spp. of ficus. (Fig. 11, Thys. Mem.)
			PLANTAIN (*Musa sapientum*).		
Stem-borer beetle.	Malabar and Ganjam.	The grub bores into the stem of the plant lower down and often killes the plant.	*Cosmopolites sordidus*, G. (Curculionid—weevil).	Only preventive; completely remove infested banana st ump, don't leave stumps after the plantain bunches are cut. Collect beetles when found and destroy.	The insect is a medium sized dark beetle with a prominent snout and the grub pale white. (Fig. 201, S.S.I.)

Tobacco caterpillar.	**Malabar, Tanjore and Godavari.**	**Feeding on leaves** ..	***Prodenia litura.*** **F. (Noctuid—moth).**	**Cutting off infested leaves will alone be quite effective.**	
Other caterpillars.	**Northern Circars, Malabar and South Kanara.**	Do. ..	***Parasa lepida*, Fb. Slug, (Limacodid—moth), *Pericallia ricini*, F. (Arctiad—moth).**	Do.	*See* Fig. 232 "*Pericallia*" is a black hairy caterpillar.
Lace wing bug.	**Northern Circars and Malabar.**	Sucking tender foliage.	*Stephanitis* (*Cadamastus*) *typicus*, D. (Tingidid—bug).	Rarely serious	Minute bugs with lace like wings.
Scale insects ..	Nilgiris (Walayar), Godavari, and Tirunelveli.	Sucking tender tissues ..	*Aspidiotus destructor*, Sign, *A. cyanophylli*, *S.* and *Lecanium descrepans*, Gr. (Coccid—bugs).	Not serious pests generally found on fruits.	*See* Cocc. Bull, Pl. VII, Fig. and Pl. VII, fig. 3.
Spittle insect ..	South Kanara, Coorg and Malabar.	Do. ..	*Phymatostetha deschampsi*, L. (Cercopid—bug).	Collect by nets	A black and red insect; rarely a pest though often found in numbers.
		JAK (*Artocarpus integrifolia*).			
Shoot borer caterpillar.	Godavari, Malabar and South Kanara.	The caterpillar bores into tender shoots and buds.	*Margaronia caesalis*, W. (Pyralid—moth).	Preventive. Clip off and destroy all infested and rotten tender shoots to check spread.	When serious several buds drop. (Fig. 311, S.S.I.)
Jak bud weevil.	Mysore and Malabar.	Grub bores into the tissue of young fruits.	*Ochyromera artocarpi*, M. (Curculionid-weevil).	Same remedy as above; badly infested tender fallen fruits to be collected and destroyed to check spread.	A small grey brown weevil. Not found so far outside the Mysore uplands and West Coast.
Jak aphid ..	Do.	Colonies suck sap from shoots.	*Greenidea artocarpe*, W. (Aphidid-bug).	Cut badly infested shoots.	
Mealy bugs ..	Nilgiris foothills and Malabar.	Covering soft parts and sucking juice.	*Icerya aegyptiaca*, D. *Pseudococcus corymbatus*, Gr. (Coccid—mealy bug).	Sometimes serious and attended by swarms of ants. Spraying with a contact insecticide.	Pl. I, fig. 4. Cocc. Bull.
Jak spittle insects.	Coorg and Mysore hill tracts.	Sometimes found in numbers and doing appreciable damage.	*Cosmoscarta relata*, Dt. (Cercopid—bug).	One or two other species. *Ptyelus sp.* and *Clovia, lineaticollis* are also found on jak in Malabar.	A minor pest only.
Jak scale ..	Mysore	Covering leaves and twigs in swarms and sucking sap.	*Aspidiotus triglandulosus*, Gr. (Coccid—bug).	Sometimes serious and attended by swarms of ants. Spraying with a contact insecticide.	Minute ashy black scales. Generally clustering along the leaf ribs. (Pl. X, fig. 1, Cocc. Bull.)

I.—Insects affecting important cultivated plants in South India—*cont.*

Insect.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			FRUIT PLANTS—*cont.*		
			BREAD FRUIT TREE (*Artocarpus incisa*).		
Mealy bugs ..	West Coast ..	Covering tender shoots and sucking sap.	*Icerya aegyptiaca*, D. (Coccid—bug).	Sometimes serious and attended by swarms of ants. Spraying with a contact insecticide.	Sometimes bad covering shoots in white masses. Pl. 1, fig. 4 Cocc. Bull.
			TAMARIND (*Tamarindus indicus*).		
Scale insects ..	Coimbatore, South Arcot, Tirunelveli and Mysore.	Colonies cover fruits and leaves and suck up sap; fruits suffer badly.	*Aspidiotus orientalis*, N. *A. tamarindi*, G. (Coccid—scales).	Prune heavily infested parts and spray with contact insecticide.	*A. tamarindi* has been noted chiefly in Coimbatore, see Pl. VIII (2), Cocc. Bull.
Mealy bugs ..	Coimbatore ..	White masses cover fruits and leaves.	*Pseudococcus lilacinus*, C. (Coccid—mealy bug).	Do. ..	(See Pl. XXIII, fig. 1, Cocc. Bull).
Crab caterpillar.	Do. ..	Feeding on shoots and leaves.	*Stauropus alternus*, W. (Notodontid—moth).	Handpick the caterpillars.	Occasionally bad. See under redgram.
Bag worms ..	Do. ..	Do.	Not named (Psychid—moth).	Pick off the bags containing the larvæ or poison leaves with arsenate.	Sometimes sporadic.
			WOOD-APPLE (*Feronia elephantum*).		
Slug caterpillar.	Coimbatore, Mysore and South Arcot.	Feeding on leaves ..	*Parasa lepida*, Cr. (Limacodid-moth).	See under castor	Occasionally serious.
Fruit borer ..	Coimbatore ..	Larvæ bore into fruit and feed on contents.	*Euzophera plumbeifasciella*, H. (Pyralid—moth).	Destory first attacked fruits.	Rarely serious.
			NELLI (*Phyllanthus emblica*).		
Fruit bug ..	Northern Circars ..	Sucking fruits	*Scutellera nobilis*, F. (Pentatomid—bug).	Hand pick or net the bugs and nymphs.	Noted as a local pest only.

Mealy bug ..	**Madras and South Arcot.**	**Covering shoots and leaves in white masses.**	***Pseudococcus sp.*** **(Coccid—mealy bug).**	**Prune badly infested parts and spray contact insecticides.**	**Sometimes a mealy-wing is also seen on the leaves.**
Leaf roller ..	**Madras and Malabar.**	**The small caterpillar feeding inside leaf rolls.**	**Not named. (Microlepidoptera).**	**Clip rolled leaves**	**A minor pest.**
			EUGENIA (*Eugenia jambolana*).		
Leaf caterpillar.	**Mysore and Coimbatore.**	Feeding on foliage ..	*Carea subtilis*, W. (Noctuid—moth).	Collect caterpillars by hand.	Rarely serious. Caterpillar has the anterior part of the body conspicuoulsy swollen.
Fruit-fly ..	Ceded Districts, Northern Circars and Coimbatore.	Maggots burrow into fruit pulp.	*Bactrocera correctus* (Trypæ-nid—fly).	Destroy badly infested fruits.	Sometimes bad.
Mealy wings ..	Northern Circars, Coimbatore and Mysore.	Colonies cover shoots and tender leaves and suck sap.	*Dialeurodes eugeniæ*, M. (Aleurodid—bug). Sometimes a Psyllid (*Trioza sp.*) is also noted on Eugenia.	Clip badly infested shoots and if necessary spray with contact insecticide.	A minor pest.
			JUJUB (*Zizyphus jujuba*).		
Fruit borer ..	Ceded Districts, Coimbatore and Mysore.	The reddish caterpillar bores into the fruit pulp.	*Meridarches scyrodes*, M. (Carposinid–moth).	Same remedy as for fruit flies on mango, pumpkin, etc., see above.	The fruit fly maggot and this reddish caterpillar are often found together.
Fruit-fly ..	Do.	The maggot burrows into the pulp of the fruit.	*Carpomyia vesuviana*, B. (Trypetid—fly).	Same remedy as for the fruit borer above.	This fruit fly is different from all others noted before. It is confined to this plant in Southern India. It is smaller in size also.
Hairy caterpillar.	Coimbatore.. ..	Swarms of caterpillars feed on the foliage.	*Thiacidas postica*, W. (Lymantrid—moth.)	Prune badly infested branches and spray arsenate.	Sometimes bad.
Leaf butterfly.	All over Southern India.	The small fleshy larvæ feeds on the foliage.	*Tarucus theophrastus*, F. (Lycænid—butterfly).	Rarely bad	Ants visit these caterpillars.
Leaf weevil ..	Coimbatore ..	Feeding on foliage ..	*Myllocerus transmarinus*, Hb (Curculionid—weevil).	Shake the branches when the beetles will drop and then collect and destroy them.	Fairly large beetle.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			FRUIT PLANTS—*cont.*		
			JUJUB (*Zizyphus jujuba*)—cont.		
Leaf hispid ..	Coimbatore ..	Larvae and adults feed on the foliage.	*Platypria andrewesi*, W. (Hispid—beetle.)	Shake the branches when the beetles drop and collect leaves containing the larvæ.	Small spiny beetle.
Scal insects ..	Bellary and Coimbatore.	Colonies cover leaves and shoots and suck sap.	*Ceroplastodes cajani*, M, *Pulvinaria maxima*, Gr. (Coccid—scale insects).	Prune badly infested shoots and spray contact insecticide.	Sometimes bad (figures Pl. XV-2 and Pl. XIII, Cocc. Bull).
			CUSTARD APPLE (*Anona squamosa*).		
Mealy bug ..	Coimbatore, South Arcot, Malabar and Anantapur.	Colonies cover the tender portion and suck sap.	*Pseudococcus virgatus*, C., *P. lilacinus*, C. (Coccid—mealy bugs).	Spray with contact insecticides after pruning the badly infested parts.	Sometimes very serious covering whole fruits and stalks.
Fruit borer ..	All over Southern India.	Caterpillar bores into the fruits.	*Heterographis bengalella*, R. (Pyralid—moth).	Destroy first attacked fruits.	A minor pest.
Fruit-fly ..	Coimbatore and Anantapur.	Maggots bore into fruits.	*Bactrocera persicæ*, B. (Trypetid—fruit-fly).	Do. ..	Sometimes bad.
			COUNTRY ALMOND (*Terminalia catappa*).		
Leaf beetle ..	Throughout Southern India.	The leaves are twisted by the creature into knots and the larvae develop in these.	*Apoderus tranquebaricus*, F. (Curculionid—beetle).	Clip off the knotted and twisted leaves and kill beetles when found.	Occasionally numerous, but easily checked.
Scales	Coimbatore, Mysore and South Arcot.	Colonies of young and adult cover tender parts and suck plant sap.	*Saissetia nigra*, N., and *S. hemisphaerica*, T. (Coccid—scales).	Prune badly infested parts and spray contact insecticide.	Sometimes bad.
Thrips ..	Coimbatore and Malabar.	Colonies cover tender parts and suck up sap.	*Rhipiphorothrips cruentatus*, H. (Thripidae—thrips).	Prune badly infested leaves.	A minor pest found on grape and rose also. Thy. Mem. p. 252 and fig. 16.

			CASHEW (*Anacardium occidentale*).		
Thrips ..	Malabar	Cover foliage and shoots and blighten the surface.	*Selenothrips rubrocinctus*, G.C. Thripidae—thrips).	Clip badly infested parts and spray with tobacco decoction.	Sometimes a serious pest. Attacks cacao.
Leaf caterpillar.	Do.	Feeding on foliage ..	*Cricula trifenestrata*, H. (Saturnid—moth).	Spray with arsenate if bad.	A big brown moth found on pepper leaf also.
Leaf capsid ..	Cochin, Malabar ..	Sucking sap from tender parts.	*Helopeltis antonii*, S. (Capsid—bug).	Net bugs when found ..	Attacks tea.
Shoot weevil ..	South Kanara, Mysore.	Feeding on shoots and buds.	*Apion amplum*, F. (Curculionid—weevil).	May be easily handpicked and netted.	Small dark insect.
Scale insects ..	Do.	Covering tender parts and sucking sap.	*Ceroplastes floridensis*, C. (Coccid—bug).	Clip leaves with the scales.	Waxy oval scales easily seen. Cocc. Bull. p. 40.
Stem girdler ..	In cashew nut growing areas.	Rings the stem and often kills them.	*Plocœderus Ferrugineus* Linn. (Cerambycidae) *P. Consocius*. Pascoe.	Handpicking the adults as they emerge at dusk. Destruction of infested trees.	Dark brown beetle about 1½″ in length.
			SAPOTA (*Achras sapota*).		
Leaf hoppers ..	Northern Circars ..	As on mango	*Idiocerus niveosparsus*, and allied spp. (Jassid—bugs).	See under mango ..	Not so serious as on mango.
Mealy bugs ..	Do. ..	Covering shoots and stalks and sucking sap.	*Phenacoccus iceryoides*, Gr., *Pseudococcus lilacinus*, F. (Coccid—bugs).	Prune badly infested shoots and spray with contact insecticides.	Occasionally serious. Cocc, Bull., Pl. XXV and XXIII.
			PINE APPLE (*Ananas sativus*).		
Mealy bug ..	North Malabar ..	Colonies of small white reddish insects suck the juice from the fruits.	*Pseudococcus bromeliae*, B. (Coccid—mealy bug).	Destroy badly infested apples.	Rather new to India.
			MULBERRY (*Morus sp.*).		
Stem girdler ..	Coimbatore.. ..	Beetle rings the stem and often kills it.	*Sthenias grisator*, F. (Cerambycid—beetle).	Destroy infested stems and kill beetles when found.	See under grape.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			FRUIT PLANTS—*cont.*		
			BAEL OR BILWA (*Aegle marmelos*).		
Leaf beetle ..	Coimbatore and Malabar.	Grubs and beetles defoliate plants often badly.	*Clitea indica*, J. (Chrysomelid—beetle).	Clip leaves containing gregariously feeding grubs and if necessary dust or spray arsenate.	A small dark shining beetle with orange-yellow grubs.
Scale insects ..	Do. ..	Colonies cover leaves and suck up sap.	*Lecanium viride*, Gr. (Coccid—scale).	Prune badly infested shoots and spray contact poison if necessary.	See under citrus, coffee (Plate XVII, Fig. 2, Coccid bulletin).
			APPLES, PEARS AND ALLIED FRUITS (*Pyrus spp*).		
Woolly blight..	Nilgiris, Shevaroys and Mysore.	Colonies of these small insects attack the roots and stem and cause galls.	*Eriosoma lanigera*, H. (Aphidid—bug).	Remove and destroy badly infested parts and spray the plants. Now being biologically controlled in the Nilgiris by the systematic colonisation of its specific parasite *Aphelinus mali*.	An introduced pest found only on the hills so far; very bad sometimes. (Fig. 389, S.S.I.)
Plant-lice ..	Nilgiris and Shevaroys.	Colonies cover shoots and suck plant sap.	*Dilachnus krishni*, G. (Aphidid—bug).	Spray contact insecticide.	Sometimes bad.
Leaf weevil ..	Mysore	Feeding on foliage ..	*Myllocerus subfasciatus*, G. (Curculionid—beetle).	Handpick or net beetles ..	Not very serious generally.
Scales	Do.	Colonies suck sap ..	*Aspidiotus cydoniae*, C. (Coccid—scales).	Prune badly infested shoots and spray contact insecticide.	Also found on Fig. (Plate VIII (1), Cocc. Bull.)
			PEACH, PLUM (*Prunus spp.*).		
Fruit flies ..	Nilgiris	Maggots bore into fruits.	Chiefly the species *Chaetodacus ferrugineus*, B. (Trypaenid—fly).	Destroy first attacked fruits and trap flies by poisoned syrup spray.	Bad on the Nilgiris fruit farms. See under mango, guava, etc.

DYES, DRUGS, SPICES, NARCOTICS, Etc.

Indigo (*Indigofera arrecta*).

Leaf weevil ..	Ceded Districts, Tirunelveli, South Arcot, Coimbatore.	The weevil and grubs feed and breed on the tender shoots.	*Alcides bubo* F. (Curculionid—beetle).	Beetles may be collected and infested shoots pruned. Spray or dust with BHC or DDT.	Attacks agathi and cluster beans.
Indigo psylla ..	Ceded Districts, Tirunelveli, South Arcot, Coimbatore.	The small insects suck the juice in numbers and make the shoots and leaves curl and fade.	*Arytaina punctipennis*, Cr. = (*P. isitis*, B.) (Psyllid—bug).	Spray contact insecticide when bad.	Pl. XLVII, S.S.I.
Leaf caterpillars.	Do.	Feed on the leaves ..	More than one species noted; chief are—*Laphygma exigua*, H., *Plusia orichalcea*, F. (Noctuid—moths) *Dichomeres ianthes*, M. (Gelechiad—moth).	Handpick caterpillars or spray arsenate if pest is bad.	These are not commonly serious in South India.

Nuna (*Morinda tinctoria*).

Scales	Coimbatore	Cover leaves and cause blight.	*Aspidiotus orientalis*, N., *Lecanium viride*, S. *Pulvinaria psidii*, M. (Coccid—bugs).	Cut badly infested branches and spray contact insecticide.	Sometimes the scales do severe damage. Cocc. Bull. Pl. XXI (1).
Shoot beetle ..	Do.	Larvae bore into shoots and kill them.	*Hypothenemus plumeriae*, N. (Scolytid—beetle).	Prune infested shoots ..	During certain seasons numerous shoots are found dry and drooping due to the attack of this insect.
Sphinx caterpillars.	Do.	Feed on the leaves ..	*Macroglossa vialis*, B. and other *spp.*; also *Rhopalopsyche bifasciata*, B. (Sphingid—moths).	Handpick larvae which are stout and conspicuous.	Pretty and active moths.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
		DYES, DRUGS, SPICES, NARCOTICS, ETC.—*cont.*			
		TURMERIC (*Curcuma longa*) AND ARROW-ROOT.			
Shoot borer ..	All over South India.	The caterpillar bores into the growing shoot and often kills it.	*Dichocrocis punctiferalis*, G. (*Pyralid*—moth).	Only prevention. Destruction of attacked shoots. Same as the insect attacking castor seed capsules.	*See* under "castor" above.
Turmeric butterfly. ..	Do.	The caterpillar feeds on the leaves often inside folds.	*Udaspes folus*, Cr. (Hesperiid—butterfly).	Handpicking of the caterpillars and pupae inside leaf folds very easy and effective. The butterflies can also be netted and destroyed.	A stout greenish caterpillar with dark head; butterfly is white and black spotted. (Fig. 295, S.S.I.).
Scale	Salem	Colonies of the scale cover the underground haulms and makes them fade.	*Aspidiotus hartii*, C. (Coccid—scale).	Mix irrigation water with contact insecticide; use insect-free seeds.	Sometimes serious.
Lace-wing bug.	All over South India.	Colonies of these small insects suck the juice from the leaves.	*Stephanitis typicus*, D. (Tingidid—bug).	Handpicking of leaves containing colonies, or in bad attacks spray leaves with a very dilute solution of crude oil emulsion.	Very small insects found in colonies on the back of the infested leaves. Same kind of insects as brinjal lace-wing bug noted under brinjal. (Fig. 369, S.S.I.)
Thrips ..	Chittoor, Malabar, Cuddapah and Travancore.	Swarm on tender parts and suck sap.	*Panchaetothrips indicus*, B. (Thripid—thrips).	Net the creatures and spray with tobacco washes if necessary.	Active little insects sometimes found in numbers Fig. 23. Thys. Mem.
		GINGER (*Zingiber officinalis*).			
Shoot borer ..	Malabar	Larva bores into shoot and often kills it.	*Dichocrocis punctiferalis* G. (Pyralid—moth).	As in turmeric	*See* under turmeric and castor.

Fly	Do.	Maggot found in rotting ginger.	Two species are noted: *Calobata sp.* (Micropesid—fly), *Formosina flavipes*, M. (Chloropid—fly).	Destroy first attacked plants with the maggots.	Found also on turmeric; status doubtful.
			CUMMINS, CORIANDER, ANISEED, ETC.		
Leaf caterpillar.	Coimbatore and Northern Circars.	Feeding on leaves and tender buds.	*Laphygma exigua*, H. (Noctuid—moth).	Same as noted on onion ..	*See* under "onion" above.
Flower-head bug.	Northern Circars ..	Sucking the juice from flower buds.	*Agonoscelis nubila*, F. (Pentatomid—bug).	Checked easily by netting the insects.	Not serious generally, (Fig. 351, S.S.I.)
			PEPPER (*Piper nigrum*).		
Flea beetle ..	Malabar	The small grub of the bettle bores into the green pepper berry.	*Longitarsus nigripennis*, M. (Chrysomelid—beetle).	Spraying of some deterrent which will keep away the beetle.	A small red and black insect found scraping leaves and berries of pepper.
Scales	Malabar and Travancore.	Scales suck the juice from the vine and shoots and are found in thousands on the vines.	*Lepidosaphes piperis*, G., *Pinnaspis aspidistræ*, S. (Coccid—Scales).	Removal of badly infested vines and in bad cases spray with a strong contact poison like "resin compound".	Colonies of these small boat-shaped scales sometimes completely cover the pepper vines and leaves killing them in some cases. (Fig. 1, Cocc. Bull).
Mealy bug ..	Malabar	White masses of these insects sometimes cover leaves and shoots.	*Pseudococcus virgatus*, C. (Coccid—mealy bug).	Prune and spray with contact washes.	*See* under tomato, custard apples, etc. Pl. XXI (2), Cocc. Bull.
Leaf caterpillar.	Do.	Feeding on foliage; does not damage pepper as it does the standard on which pepper twines.	*Cricula trifenestrata*, H. (Saturnid—moth).	See under cashew	Often heavily parasitised.
			BETEL VINE (*Piper betel*).		
Betel-vine bug.	South Kanara, Bellary and Kurnool.	The bugs suck the juice from tender leaves which curl up and fade.	*Disphinctus politus*, W. (Capsid—bug).	Dust with BHC D 025.	Belongs to the same group as the cholam ear-head bug but is reddish brown in colour (Fig. 375, S.S.I.)

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
		DYES, DRUGS, SPICES, NARCOTICS, ETC.—*cont.*			
		CARDAMOM (*Elettaria cardamomum*).			
Cardamom thrips.	In all cardamom areas of the province.	Causes severe scabbing of the pods and also shedding of the flowers.	*Taeniothrips cardamomi* Ram. (thripidae).	Spray Nicotene sulphate 0.05 per cent or dust B.H.C. D025 at 5 lb. per acre.	A very serious pest in all cardamom tracts, responsible for the downfall of the industry.
Root borer ..	In most cardamom tracts.	Caterpillars bore into the roots, causing considerable damage.	*Hilarographa caminodes*, Meyr.	Definite remedy not yet evolved.	Occasionally serious.
Rhizome borer.	In many cardamom tracts.	Grubs bore into the rhizome making tortuous tunnels.	*Prodioctes haematicus* (curculionidae).	Do.	....
Stem borer ..	Hill tracts along the Western Ghats.	Larva boring into stem and often killing it.	*Dichocrocis punctiferalis*, G. (Pyralid—moth).	See under turmeric and ginger.	A minor pest.
Capsule borer.	Coorg	Beetle boring and destroying capsules.	Scolytid beetle ..	Collection and destruction of first attacked capsules. No other method known so far.	A minute dark brown beetle (Fig. 203, S.S.I.)
		CINNAMON (*Cinnamomum zeylanicum*).			
Leaf psyllid ..	South Kanara ..	Larvae and adults causing galls in shoots and leaves and sucking sap.	*Pauropsylla depressa*, C. (Psyllid—bug).	Clip galled leaves and shoots.	Commonly noted.
		COFFEE (*Coffea arabica*).			
White borer ..	Nilgiris, Coorg, Mysore, South Kanara.	The white grub bores into the stem and kills it often.	*Xylotrechus quadripes*, Ch. (Cerambycid—beetle).	Pruning of dead and dying shoots and scrubbing the bushes to remove loose bark to prevent egglaying. Enforcement of Pest Act.	A black and white-spotted beetle with long feelers. (Fig. 178, S.S.I.) A serious pest of coffee.

Red borer ..	In different parts of the South Indian hill districts.	Red caterpillar bores into the shoot and stem.	*Zeuzera coffeo*, N. (Zeuzerid—moth).	The branches containing the borer may be lopped off as they are easily located.	Not a common pest of coffee. (Fig. 323, S.S.I.)
Mealy bug ..	Do.	Colonies of these attack the roots of the coffee seedlings.	*Pseudococcus citri*, R. (Coccid—mealy bug).	The soil may be irrigated with water mixed with crude oil emulsion.	(Pl. XX, Fig. 2, Coccid Bulletin.)
Green bug ..	Throughout South Indian hills.	Colonies of this scale insect cover the leaves and suck the juice.	*Lecanium viride*, G. (Coccid—scale).	Cut and burn badly infested shoots and spray with fish-oil soap. Destroy ants' nests in the vicinity.	Sometimes bad on coffee in some plantations, the scale is killed in numbers during the rainy season by a fungus. Cocc. Bull. Pl. XVII (2).
Brown bug ..	Do.	Do.	*Saissetia hemisphaerica*, T. (Coccid—scale). Other scales sometimes noted on coffee are *Pulvinaria psidii*, M., and *Saissetia nigra*, N.	Do.	Fig. 5, Coc. Bull.
Leaf caterpillars.	Along the Western Ghat.	Feeding on leaves and often seedlings.	*Euxoa segetum*, Sch (Noctuid—moth) Other caterpillars occasionally noted are *Belippa laleana*, M. (Slug—Limacodid), *Olene mendosa*, H. (Hairy caterpillar—Lymantrid) and *Homona coffearia*, N. (Flush-worm—Tortricid—moth).	See under potato, red-gram, caster, and tea.	Euxoa is a cutworm and attacks numerous plants on the hills. (Fig 237, S.S.I.) For *Olene* and *Homona*, see Figs. 264 and 330, S.S.I.
Coffee shoot and berry bug.	Nilgiris and Shevaroys.	Sucks shoots and berries.	*Antesta cruciata*. F. (Pentatomid—bug).	Collect or net the bugs ..	(Fig. 350, S.S.I.) Found on jasmine also.
Cockchafer ..	Coorg, Mysore and Travancore.	The grub attacks the seedlings and adults attack foliage.	*Holotrichia conferta*, S. (Coorg and Mysore). *Serica pruinosa*, B. (Travancore) (Melolonthid—beetles).	Put up light traps for adults and irrigate seedlings with poisoned water.	These are occasionally bad.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			DYES, DRUGS, SPICES, NARCOTICS, ETC.—*cont.*		
			COFFEE (*Coffea arabica*)—*cont.*		
Leaf beetles ..	Coorg, Shevaroys, Nilgiris.	Feed on foliage	*Sympiezomias frater*, M. (Curculionid—beetle). *Corynodes sp.* (Chrysomelid—beetle).	Jar the weevils from the plants and destroy them.	Though found in numbers are minor pests only. *Corynodes* is a shining bluish-green beetle.
Coffee shoot borers.	Coorg, Malabar ..	Bore and breed in shoots and twigs of growing and dead stems.	The species noted are—*Xyleborus compactus*, E., *X. fornicatus*, E. and *X. morstatti*, E. (Scolytid—beetles).	Prune badly infested branches and burn them with insects.	*X. fornicatus* is found on castor also. (Fig. 294, S.S.I.)
Coffee leaf hopper.	Nilgiris	Larvae and adults sucking sap from tender parts; sometimes found in numbers.	*Ricania bicolorata*, D. (Fulgorid—bug).	Net the bugs and spray the plants with deterrent insecticide when necessary.	An active black insect found in numbers during summer in the Nilgiri slopes.
Coffee berry beetle.	Western Ghats, Mysore.	Beetle bores into pulp of berries; also found in stored berries.	*Araecerus fasciculatus*, Dg. (Anthribid—beetle), the Scolytid. *Stephanoderes hampeii* has not yet been definitely noted on Indian-grown coffee.	Destroy infested berries and fumigate stored coffee.	Found attacking arecanuts also.
Coffee grasshopper.	Do.	Feeding on foliage; occasionally found in some numbers.	*Aularches miliaris*, D. (Acridiid—grasshopper).	Net the grasshoppers ..	Rarely a pest. (Fig. 418, S.S.I).
			TEA (*Camellia theifera*).		
Tea mosquito.	All along Western Ghats and Nilgiris.	Sucking up sap from tender parts and leaves and making them fade; often serious.	*Helopeltis antonii*, S. Occasionally another common hill Capsid. *Disphinctus humeralis*, W., is also seen.	Netting the bugs and spraying D.D.T.	(Fig. 374, S.S.I.) often a very bad pest in all the tea districts.

Leaf carter-pillars.	In different tea districts of South India.	Caterpillars found feeding on foliage in different ways as open feeders, feeding in folds of leaf, etc.	Chief of the species noted in South India are—*Heterusia virescens*, B., *Buzura suppressaria*, G, *Homona coffearia*, N., *Laspeyresia leucostoma*, M., *Contheyla rotunda*, H., *Dasychira horsfieldi*, S., *Thosea cervina*, M.	Zygaenid—moth. Geometrid „ Tortricid „ Eucosmid „ Limacodid „ Lymantrid „ Limacodid „ Different methods for different species; hand-picking, pruning, scraping stems containing cocoons, etc.	For Heterusia and Buzura. See Figs. 326 and 281, S.S.I.
Shot-hole borer.	Travancore and Malabar.	Bore holes into twigs and shoots.	*Xyleborus fornicatus*, E., *X. semigranosus* (Malabar) (Scolytid—beetles).	Prune badly infested shoots.	*See* under coffee.
Stem-borers ..	In the tea districts.	Larvæ bore into stem ..	*Zeuzera coffeae*, N. (Zeuzerid—moth). *Indrabala theeivora*, H. (Small dark brown—moth). *Phassus malabaricus*, M. (Hepialid—moth).	Same as under coffee ..	Only occasionally serious. For *Phassus* see Fig. 344, S.S.I.
Scale insects ..	Do.	Cover shoots and leaves in colonies.	Chief species are—*Aspidiotus camelliae*, Sign, *Saissetia hemisphaerica*, T. (Coccid—bugs).	Prune badly infested branches and spray contact insecticide, if necessary.	*Camelliæ* is sometimes bad. Cocc. Bull. Pl. VII (2).
Thrips ..	Nilgiris	Attacking tender parts.	*Dendrothrips bispinosus*, B. (Thripid—thrips).	Of very minor importance.	Noted once on the Nilgiris. Thys. Memr., p. 252.
Tea mites ..	In all tea districts.	Cover the plants in colonies and suck the juice.	Two species—*Phytopus carinatus* and *Tetranychus bioculatus* (mites).	Dusting with flowers of sulphur effective.	The purple and red mites of tea. (Figs. 440 and 439, S.S.I.) *Not insects.*

I.—Insects affecting important cultivated plants in South India—*cont.*

Insect.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
		DYES, DRUGS, SPICES, NARCOTIES, ETC.—*cont.*			
		COCOA (*Theobroma cacao*).			
		(In South India it is grown only in Government Gardens, Kallar.)			
Mealy bug ..	Nilgiri slopes ..	Covering shoots and pods.	*Pseudococcus citri*, R. (Coccid—mealy bug).	Prune badly infested branches and spray contact insecticide, if necessary.	(Pl. XX, Fig. 2, Cooc. Bull.)
		TOBACCO (*Nicotiana tabacum*).*			
Tobacco caterpillar.	Northern Circars, Coimbatore, Tanjore and Madura.	Feeding on the foliage either in the nurseries or planted areas.	*Prodenia—litura*; F. (Noctuid—moth); other species occasionally found are *Chloridea assulta*, G. and *Plusia signata*, F.	The first is the same as the one on castor, agathi, tomato, etc. Egg clusters and leaves containing numerous caterpillars may be collected and destroyed. In bad cases spray with a stomach poison.	*Prodenia* is often serious and found on various other plants. (Figs. 1 and 2, Tob. Bull.)
Stem-borer ..	Northern Circars, Ceded Districts, Coimbatore and South Arcot.	The small caterpillar bores into the stem and produces galls on the stem.	*Phthorimoea heliopa*, L. (Gelechiad-moth).	Only preventive being a borer; cut out the larvæ in first attacked plants, Destroy attacked seedlings before transplantation from nursery.	Both the caterpillar and moth are small. Attacked plants can be easily made out from the swelling at the stem. [Col. Pl. XLIII, S.S.I. Fig. 4 (*c—g*), Tob. Bull.]
Gram caterpillar.	All over South India.	Caterpillar boring into seed capsules.	*Heliothis obsoleta*, F. (Noctuid—moth).	See under red-gram; cover the flower heads with muslin to prevent attack.	Occasionally serious. (Fig. 5, Tob. Bull.)
Plant-lice ..	In all tobacco tracts.	Colonies of these infest the leaves, suck the juice and affect their vigour.	*Myzus persicæ*, S. (Aphidid—bug).	In bad infestation spray with tobacco decoction which is very effective.	A pest often reported from South Kanara, Guntur, Tanjore and Coimbatore districts. (Fig. 4, Tob Bull.)

Capsid ..	Do.	Swarms settle on tender parts and suck sap.	*Gallobelicus crassicornis*, D. (Capsid—bug).	Net the bugs and if necessary, spray tobacco decoction as deterrant.	Fig. 6 (i), Tob. Bull.
Grasshoppers.	Do.	Feed on the seedlings in the nursery and on the foliage in the fields.	*Atractomorpha crenulata*, Fb., *Chrotogonus robertsoni*, B. (Acridiid—grass-hoppers).	Net and trap them with poison baits.	Fig. 3, Tob. Bull.
Leaf noctuid ..	Do.	Feed on the leaves ..	*Laphygma exigua*, Hb. (Noctuidæ).	Grow trap crop of ragi round seed beds. Destroy egg masses and caterpillars.	*See* Ragi.
Root-sucking bug.	Coimbatore ..	Young and adults attach themselves to roots and rootlets and suck sap ; this causes fading and even death of affected plants.	*Stibaraopus tabulatus*, *Fb.* (Pentatomid—bug).	Irrigate the plants infested with contact insecticide and water.	Fig. 7, Tob. Bull.
Ground beetles.	Guntur	Nibbling roots and shoots of seedlings.	*Opatroides frater*, F. and *Seleron latipes*, G. (Tenebrionid—beetles).	Rake up soil and poison irrigation water with contact insecticide.	*See* under potato.
			GANJA (*Cannabis sativa*).		
Gram caterpillar.	Ganja areas in the Presidency (North Arcot, Guntur, etc.).	Feeds on the foliage ..	*Heliothis obsoleta*, F. (Noctuid—moth).	See under gram	Worst caterpillar pest of ganja.
Leaf caterpillar.	Do.	Feeding on the leaves ..	Those often found are the following *spp.* *Amyna octo*, G. *Laphygma exigua* *Prodenia litura* (Noctuid—moths).	Handpick caterpillars early in the season. Not advisable to spray arsenates on the leaves.	One or other of these at times become serious.
White ant ..	Do.	Workers attacking growing plants.	*Microtermes obesus*, R. (Termitidæ—white-ant).	Irrigate water mixed with insecticide.	Sometimes bad.
Thrips ..	Do.	Swarm on tender shoots and suck sap.	*Heliothrips indica*, B. (Thripid—thrips).	Dust with fine tobacco powder.	See under groundnut and Onion. Thys. Mem. Fig. 1.
Ganja mite ..	Do.	Do.	*Tetranychus telarius*, L. (Acari—mite).	No effective remedies known.	This pest is often bad in Upper India also. *Not an insect.*

* For detailed information on tobacco pests see bulletion on tobacco insects in South India (Agr. Dept. Bult No. 26.)

I.—Insects affecting important cultivated plants in South India—*cont.*

Insect.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			DYES, DRUGS, SPICES, NARCOTICS ETC.—*cont.*		
			CINCHONA (*Cinchona ledgeriana*).		
Chafer beetles.	Nilgiris	Grubs attack the roots.	The chief of the species noted are—*Holotrichia repetita*, S., *Rhizotrogus rufus*, A., *Serica nilgiriensis*, S., *Popilla chlorion*, N., (Rutelid and Cetoniad—beetles).	Light traps may be put up to catch adults. Plants may be irrigated with insecticide mixed with water and grubs collected.	Sometimes very bad on the Nilgiris.
Leaf and shoot capsid.	Anamalais	Sucks up juice from young plants.	*Disphinctus humeralis*, W. (Capsid-bug).	Net the bugs	Occasional pest. See under "Tea."
Leaf weevils ..	Nilgiris	Feeds on foliage ..	*Sympiezomias decipiens*, M. (Curculionid—beetle).	Jar beetles and dust plants with arsenate.	A minor and often sporadic pest.
			PALMS.		
			COCONUT (*Cocos nucifera*).		
Rhinoceros beetle.	All over South India, chiefly along the West Coast.	The beetle burrows into the growing shoot and cuts the same often killing it.	*Oryctes rhinoceros*, L. (Dynastid—beetle).	Preventive measures are the most effective. Prevent insect breeding in manure pits. Cut open and dry dead and rotting trees to check the pest breeding in them. The beetle can also be pulled out by a hooked wire from infested crowns.	The beetle is black and has a horn on the face like the rhinoceros. It is a bad pest of coconuts all over South India. Col. Pl. III, S.S.I.

Red weevil ..	Do.	The grubs burrow into the soft portions and do damage.	*Rhynchophorus ferrugineus*, F. (Curculionid—beetle).	Scars and wounds on the tree crown should be tarred to prevent the weevil laying eggs. If the rhinoceros beetle is checked the weevil will also be automatically checked since the latter often follows the former.	A red cylindrical insect with a long curved pointed snout. All the stages are found in infested trees. Pl. XLV, S.S.I.
Black-headed caterpillar.	West Coast, Northern Circars, and parts of Coromandel coast.	The caterpillar feeds on the leaf, remaining between the folds of the leaf.	*Nephantis serinopa*, M. (Xyloryctid—moth).	Cutting off attacked fronds and burning them. Only preventive method practicable. Encourage parasites.	Often a serious pest along the West Coast. Fig. 336, S.S.I.
Slug caterpillars.	Do.	Caterpillars feed on the foliage.	*Parasa lepida*, G. (all over South India), *Contheyla rotunda*, H. (found only in the West Coast till now). *Natada nararia*, M. (once noted bad in Godavari), (Limacodid—moths).	Cutting off infested fronds and destruction of cocoons on the stems.	For *Parasa See* under "Castor" and "Mango."
Skippers ..	All over South India.	The caterpillars cut young leaves and feed inside the folds.	*Gangara thyrsis*, M. (on young coconut trees chiefly), *Suastus gremius*, F. (More on palmyra). (Hesperid—butterflies).	The leaf-folds containing caterpillars can be easily handpicked.	The pest is bad only on young trees. The caterpillars are covered with white powdery wax. Figs. 290, 291, S.S.I.
Scale insects ..	West Coast, Coimbatore, Tirunelveli and Anantapur.	Colonies of these small insects cover the foliage and suck juice.	*Aspidiotus destructor*, S., this is the chief of those found and often destructive; others noted are *Aspidiotus ficus*, A., *Ceroplastes actiniformis*, G., *Vinsonia stellifera*, W., *Lecanium hesperidum* (Coccid—scales).	Cutting off and burning the badly infested fronds is the best and effective remedy.	The first is an oval transparent insect found often in colonies on the foliage; See Cocc. Bull., Pl. VII (1), Pl. XII (2), and Pl. XIV (1).

I.—Insects affecting important cultivated plants in South India—*cont.*

Insect.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			PALMS—*cont.*		
			COCONUT (*Cocos nucifera*)—*cont.*		
Mealy bug ..	West Coast and Coimbatore.	Colonies of these small insects cover the foliage and suck juice. Tender shoots suffer much.	*Pseudococcus longispinus*, T. (Coccid—mealy bug).	Cut off badly infested parts and if necessary spray contact insecticide.	Fig. 1, Pl. XXI of Coccid bulletin.
Stem weevil ..	West Coast tracts.	Numbers found breeding in stem. Status as pest doubtful.	*Calandra stigmaticollis*, G. (Curculionid—weevil).	Collect beetles and destroy.	Very probably the insect comes after some disease; small brownish weevils.
			PALMYRA (*Borassus flabellifer*).		
		(The first four insects under coconut are pests also of palmyra in South India.)			
			DATE (*Phoenix sylvestris*.)		
		(The rhinoceros beetle and the red weevil are the chief pests of this palm also.)			
			ARECA (*Areca catechu*.)		
Scale insects ..	West Coast, Mysore, Coimbatore and Nilgiris.	Colonies suck the juice.	Chief species concerned are—*Chionaspis dilatata*, G. and *Pinnaspis aspidistrae*, S. (Coccid—scales).	Prune badly infested parts and spray contact insecticide.	For the first *See* Fig. 2, Pl. VI of Coccid bulletin.
Nut beetle ..	West Coast ..	Bores into nuts	*Aroecerus fasciculatus*, D. (Anthribid—beetle).	Destroy badly infested nuts.	*See* under coffee.

FLOWER AND ORNAMENTAL GARDEN PLANTS.

Rose (*Rosa centifolia*).

Leaf caterpillars.	Coimbatore, Madras, Malabar, and Northern Circars.	Feeding on the foliage ..	*Euproctis fraterna*, M. (Lymantrid-moth) *Parasa lepida*, Cr. (Limacodid-moth), *Achoea janata*, L. (Noctuid—moth).	*See* under castor for all these insects.	The first two caterpillars are hairy, spiny and irritating to the touch. The last noted in Northern Circars.
Grape thrips ..	Coimbatore, and Northern Circars.	Swarming on tender parts and sucking sap. The tissue gets blighted.	*Rhipiphorothrips cruentatus*, H. (Thripidae—thrips).	*See* under grape-vine ..	Often very serious in Coimbatore. Fig. 16, Thys., Mem.
Red scale ..	Malabar, and Northern Circars.	Colonies are found on twigs and leaves sucking the juice.	*Aspidiotus aurantii*, M. (Coccid—bug).	Cut and burn badly infested shoots and spray with crude oil emulsion.	Sometimes whole plants are killed by this scale. It is a well-known pest of oranges elsewhere but not noted on oranges as yet in South India. Fig. 1, Pl. IX, Coccid bulletin.
*** Chafer beetles.**	Nilgiri Hills, and Coimbatore.	Adult beetles feeding on flowers.	*Oxycetonia versicolor*, F., and other Cetoniad—beetles.	Net or handpick the beetles. Light traps may also be put up.	*See* under "Cholam".
Leaf cutter bees.	Coimbatore, Nilgiris and Malabar.	Bees cutting tender leaves and removing the cut pieces to their hive.	*Megachile anthracina*, S. is the chief *sp.* noted; other *spp.* of *Megachile* have also this habit of cutting leaves of different plants.	Catch the bees or dust arsenate on leaves.	These are not the honey bees but bigger forms of the same family.

Jasmine (*Jasminum sambac*).

Red scale ..	Northern Circars ..	Covering leaves and sucking sap; often very serious.	*Aspidiotus aurantii*, M. (Coccid—scale).	Prune badly infested parts and spray contact insecticide.	*See* under "Rose". Fig. 1, Pl. IX, Cocc. Bull.
Jasmine bug ..	Ceded Districts ..	Sucking up juice from buds and flowers; sometimes serious.	*Antestia cruciata*, F. (Pentatomid—bug).	Bugs may be collected or killed by fumigation.	*See* under "Coffee". A tingid also occurs sometimes.

*** Grubs of chafer beetles such as *Anomala, Adoretus, Holotrichia*, etc., damage the roots of many garden plants.**

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
		FLOWER AND ORNAMENTAL GARDEN PLANTS—*cont.*			
		JASMINE (*Jasminum sambac*)—cont.			
Mealy bug ..	Coimbatore and Salem.	Colonies appear on tender parts and suck sap.	*Phenacoccus ornatus*, Gr. (Coccid—bug).	Clip badly infested parts and spray contact insecticide.	A beautiful delicately built white insect found sometimes in numbers on the foliage.
Thrips ..	Coimbatore and Mysore.	Colonies appear on tender parts and suck sap; flowers are often badly damaged.	*Isoneurothrips orientalis*, B. (Thripid—thrips).	May be treated in the same way as for jasmine bug.	Minute blackish active insects found inside flowers. Thys. Mem. p. 261.
Mealy wing ..	Do.	Do.	*Dialeurodes vulgaris* K. (Aleurodid—bug).	Clipping badly infested leaves and spraying with dilute crude oil emulsion.	Infested leaves appear pale yellowish and show numerous oval pupae on the under surface; these are the nymphal cases of the insect.
Leaf caterpillar.	Coimbatore and Tanjore.	Feeding on foliage ..	*Glyphodes unionalis*, F. (Pyralid—moth).	Handpick caterpillars or dust with arsenates.	Moth with transparent white wings.
		CHRYSANTHEMUM.			
Caterpillar ..	Madura	Feeds on foliage and flowers and causes severe damage sometimes.	*Lamprosema indicata*, F. (Pyralid—moth).	Spray or dust with arsenate.	Figs. 309 and 310, S.S.I. Insect is found also on pulses in different parts of India.
		OLEANDER (*Nerium oleander*).			
The oleander sphinx.	All over South India.	The stout big caterpillar defoliates the plants.	*Deilephila nerii*, L. (Sphingid—moth).	Handpicking of eggs and caterpillars very easy and effective.	The caterpillar is a very stout and long one with a spine over the tail end. Figs. 273 and 274, S.S.I.

The nymphalid butterfly.	Do.	Feeding on leaves ..	*Euploea core*, C. (Nymphalid—butterfly).	The caterpillars and pupae can be easily handpicked and the butterflies can be netted.	A common butterfly, with dark wings with white spots. The pupa is a shining gold coloured chrysalid hanging from the leaf.
			LILIES.		
Lily caterpillar.	Coimbatore, Madras and Malabar.	The pretty caterpillar bores into the fleshy leaves and leaf stalk in numbers.	*Polytela gloriosa* (Noctuid—moth).	The leaves containing these caterpillars feeding gregariously could be clipped and destroyed with the larvæ; the pupae under the soil may also be dug up.	The caterpillar is a cylindrical red and white spotted insect. Fig. 238, S.S.I.; attacks all liliaceous plants.
			MAKUTUM (*Mimusops elengi*).		
Leaf thrips ..	Coimbatore, Tanjore and Tiruchirappalli.	Larvæ and adults attack leaves and cause galls.	*Arrhenothrips ramakrishnae*, H. (Phlœothripid—thrips).	Clip badly galled parts and spray tobacco decoction.	A dark ant-like insect found inside the leaf galls and folds. Fig. 25, Thys. Mem.
			TULSI (*Ocimum sanctum*).		
Lace-wing bug.	All over South India.	Small dark insects infest leaves in numbers and suck the juice.	*Monanthia globulifera*, W. (Tingidid—bug).	Spray tobacco decoction ..	Fig. 371, S.S.I.; Minute creatures found in colonies.
Scale insect ..	Do.	Colonies of these waxy insects cluster on the shoots and suck the juice.	*Ceroplastodes cajanii*, M. (Coccid—scale).	Same as above for lace-wing bug but with a stronger solution of emulsion.	*See* under "Redgram." Cocc. Bull., Pl. XV (2).
			GARDEN CROTONS.		
Scales	All over South India.	Cover shoots and stems and suck sap.	Chief species found are *Saissetia nigra*, N., *Lecanium depressum*, C., *Lepidosaphes* sp. (Coccid—Scales).	Prune badly infested parts and spray with strong contact insecticide.	*See* under "Cotton."
Mealy bugs	Do.	Do.	*Pseudococcus virgatus*, C., *Icerya aegyptiaca*, D., *Monophlebus phyllanthi*, G. (Coccid—mealy bugs).	Do.	Sometimes one or other of these completely cover the shoots and tender leaves allowing swarms of ants to visit them.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insect.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			FLOWER AND ORNAMENTAL GARDEN PLANTS—*cont.*		
			GARDEN CROTONS—*cont.*		
Thrips ..	Bangalore and Coimbatore. ..	Cover shoots and stems and suck sap.	*Heliothrips haemorrhoidalis*, B., and *Ayyaria choetophora*, K.	Prune badly infested parts and spray with strong contact insecticide.	The first a well-known insect affecting many hot-house plants in different parts of the world.
Stem ringing beetle.	Coimbatore ..	The beetle cuts the stem; sometimes kills the plants.	*Sthenias grisator* F. (Cerambycid—beetle).	See under "Mulberry" ..	Sometimes serious.
			HOLLY-HOCK AND SHOE-FLOWER (*Hibiscus rosasinensis*).		
(Many of the insects affecting cotton are found on different kinds of shoe—flower and holly-hock such as the species of spotted boll-worms, leaf-roller, bugs, caterpillars on leaf and scales.)					
			SUN-FLOWER (*Helianthus annuus*).		
Gram caterpillar	Coimbatore and Mysore.	Caterpillar feeds on leaves and seeds.	*Heliothis obsoleta*, F. (Noctuid—moth).	See under "gram" ..	Occasionally found in numbers.
			PARIJATH (*Nyctanthes arbortristis*).		
Leaf caterpillar.	Madras and Coimbatore.	Big caterpillar feeding on leaves.	*Metanastria hyrtaca*, C. (Lasiocampid—moth).	Pick off the caterpillars.	Of minor importance; also found on country almond.
			TABERNIMONTANA.		
Leaf caterpillar.	Cochin and Malabar.	Feeding on leaves ..	*Glyphodes glauculalis*, G. (Pyralid—moth).	Handpick caterpillars or dust arsenate.	A light blue moth with a yellowish streak along front margin of forewing.

GRASSES, FODDER AND GREEN MANURE PLANTS.

LUCERNE (*Medicago sativa*).					
Caterpillar ..	Coimbatore and Godavari.	Feeding on the foliage and tender shoots.	*Laphygma exigua*, H., is the chief species (Noctuid—moth).	Netting the caterpillars. It is not safe to use arsenates which will of course kill the pest.	See under "Onions," etc.
Leaf beetles ..	Coimbatore and Godavari.	Biting small holes on the leaves; often found in numbers and doing substantial damage.	Chief species noted is the pumpkin beetle *Aulacophora abdominalis*, F. Other small flea beetles are also found occasionally.	Collect beetles with hand-net.	*See* under "Cucurbitaceæ."
GUINEA GRASS (*Panicum jumentorum*) AND OTHER GRASSES.					
Hairy caterpillar.	Coimbatore and South Arcot.	Feeding on the foliage ..	*Psalis securis*, H. (Lymantrid—moth).	See under "Paddy" ..	Rarely serious.
Swarming caterpillars.	Coimbatore, Hosur and Chingleput.	Feeding on the grass plots in fodder areas; sometimes cause serious damage.	More important of the species concerned are—*Spodoptera mauritia*, B., *Cirphis albistigma*, M. C. *loreyi* and *Pelamia frugalis* (Noctuid—moths). *Psara phacopteralis*, G. (Pyralid—moth).	Netting of caterpillars; deep ploughing; baiting with trap, etc. No satisfactory method known yet.	Some of these are pests of paddy.
Rice bug	Malabar, Ganjam and Krishna.	Feeding on the flower heads of grasses.	*Leptocorisa acuta*, Th. Probably another spp. of this genus also.	See under "Paddy" ..	Not serious generally.
BAMBOO (*Bambusa, Dendrocalanus, Ochlandra, etc.*).					
Plant lice ..	Coimbatore ..	Colonies swarm on leaves and suck sap.	*Oregma bambusae*, B. (Aphidid—bug).	Clip badly infested parts and spray contact poison.	Fig. 392, S.S.I.
Scales ..	Coimbatore and Malabar.	Do.	*Chionospis elongata*, Gr., *Asterlecanium longum* Gr. and other spp. (Coccid—scales).	Do.	Sometimes these scales very badly cover the foliage and blighten them.
Mealy bug ..	Malabar	Cover shoots in white masses.	*Peudococcus detorquens*, Gr. (M.S.).	Do.	Noted once in Walayar.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
		GRASSES, FODDER AND GREEN MANURE PLANTS—*cont.*			
		BAMBOO (*Bambusa, Dendrocalanus, Ochlandra, etc.*)—*cont.*			
Stem bug ..	Coimbatore ..	Adults and nymphs settle in numbers and suck sap.	*Purohita nigripes*, D. (Fulgorid—bug).	Collect adults and egg-masses.	Eggs and nymphs are seen in white woolly masses attached to the bamboo stem inside the sheathing.
Stem-borer ..	Bellary	Larva bores into bamboo stem.	*Stromatium barbatum*, F. (Cerambycid—beetle).	Destroy first attacked stems.	Fig. 392, S.S.I.
Shoot borer chalcid.	Malabar Forests ..	Numerous grubs found inside drying shoots.	*Eurytoma chrysothrix*, W. (Chalcidid—Wasp).	Cut off badly infested branches.	In habits this insect appear to be similar to the daincha pod wasp *Bruchophagus*.
		AGATHI AND DAINCHA (*Sesbania grandiflora, S. aculeata and S. aegyptiaca*).			
Stem-borer ..	All over South India.	The stout whitish caterpillar bores into the stem and often kills the plant.	*Azygophleps scalaris*, Fb. (Zeuzeridae—moth).	Preventive only being a borer. Cut out first attacked stems and destroy larvæ and pupae. Egg clusters may also be collected and destroyed.	A fairly serious pest, sometimes in betelvine gardens where the caterpillar is called "*Chandana puchi*" in Tamil, Fig. 324, S.S.I.
Tobacco caterpiller.	Coimbatore, South Arcot and Madurai.	The caterpillar feeds on the leaves.	*Prodenia litura*, F. (Noctuid—moth).	Same as on castor.	See under castor, tobacco, tomato, etc. Sometimes bad in Agathi nurseries in betelvine gardens.
Agathi weavil.	Do.	The weevil and the grub feed and breed on the tender shoots.	*Alcides bubo*, F. *A. fabricci*, F., is also found occasionally. (Curculionid—beetles.)	Same as on cluster bean and indigo; clipping attacked top shoots in young plants. Spray or dust with BHC or DDT.	Not bad on grown-up plants.
Shoot bugs ..	Do.	Attach themselves in number to tender parts and suck sap.	*Coptosoma cribraria*, F. *Brachyplatis vahlii* (Pentatomid—bugs).	Net the bugs; this is quite easy. Dust BHC Do 25	*See* under "Lab-lab."

Moth caterpillars.	All over South India.	Feed on the foliage and sometimes cause severe damage especially on a young crop.	*Laphygma exigua*, Hb. *Pericyma glaucinans* G. (Noctuid—moths).	Can be sprayed with arsenates when not used for fodder.	For *Pericyma see* Fig. 255, S.S.I.
Butterfly caterpillars.	Do.	Do.	*Terias hecabe*, L. *Catopsilia pyranthe*. L. (Pierid—butterflies),	Collect the butterflies with net and spray if necessary. if crop is not for fodder.	Fig. 287 and 286, S.S.I.
Seed wasp ..	Coimbatore ..	Grub develops inside seed capsule ; sometimes does serious damage.	*Bruchophagus mellipes*. G. (Chalcidid—wasp).	First attacked seeds to be destroyed.	A small shining black wasp, one of the very few plant pests among the hymenoptera in South India.
		(KOLINGI) WILD INDIGO (*Tephrosia purpurea*).			
Seed pod caterpillar.	Tanjore and Tirunelveli.	Caterpillar bores into seed pods and buds and causes swollen galls.	*Dactylethra candida*, St. (Gelechiad—moth.)	Destroy first appearing galls and spray arsenates if necessary.	Seed formation is prevented by the caterpillar.
		MURUKKAM (DADAP) (*Erythrina indica*).			
Shoot borer	Malabar, South Kanara, Bellary, Madras, and South Arcot.	Caterpillar bores into shoots and tender capsules.	*Terastia meticulosalis*, G. (Pyralid—moth).	Destroy first attacked shoots and pods.	Fig. 315, S.S.I.
Leaf caterpillar.	South Arcot and Coimbatore.	Feeds on leaves ..	*Agathodes ostentalis*, H. (Pyralid—moth).	Collect leaves with the larvae.	A minor pest ; beautifully coloured moth.
Plant bug ..	Malabar and South Kanara.	The dark bug sometimes covers tender parts in thousands and sucks sap.	*Cyclopelta siccifolia*, W. (Pentatomid—bug).	Net the bugs ; this is very easy.	Fig. 357, S.S.I.
Leaf beetle ..	South Kanara and Nilgiris.	Small spiny beetles feeding on foliage ; the larva is also found in the same situation.	*Platypria echidna*, G. (Hispid—beetle).	The spiny beetles can be easily netted.	Minor pest.
Pod bug ..	Do.	The stout dark bug sucks up juice from the pods and tender shoots.	*Anoplocnemis phasiana*, F. (Coreid—bug).	Collect the bugs by hand or net.	*See* under Cowpea.
Stem girdler ..	Coorg	The beetle rings the branches of the plant.	*Sthenias grisator*, F. (Cerambycid—beetle).	See under "Mulberry".	Sometimes bad.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			GRASSES, FODDER AND GREEN MANURE PLANTS—*cont.*		
			CALOTROPIS (*Calotropis gigantea*).		
Weevil ..	All over South India.	Larva bores into shoots and rind.	*Paranecops farinosa*, W. (Curculionid—weevil).	Destroy first attacked parts.	Of minor importance Fig. 190, S.S.I.
Stem borer ..	Do.	Larva bores into the stem.	*Monohammus nivosus*, W. (Cerambycid—beetle).	Do.	Of minor importance.
Leaf caterpillars.	Do.	Feeding on foliage ..	*Danais chrysippus*, L. (Nymphalid—butterfly).	The butterflies can be netted and caterpillars handpicked.	Rarely found as a pest though common.
Fruit-fly ..	Do.	Maggots bore into seed-capsules.	*Dacus longistylus*, W. Trypaenid—fruit-fly).	Destroy first infested capsules.	Almost exclusively found on this plant.
Grasshopper ..	Do.	Feeding on foliage ..	*Poecilocerus pictus*, F. (Acridiid—grasshopper).	Collect the grasshoppers; it is very easy.	A pretty grasshopper. Fig. 419. S.S.I. Very commonly found.
Plant lice ..	.. Do.	Fringe backside of leaves in colonies and suck sap.	*Aphis nerii*, B. (Aphid—bug).	Destroy badly infested leaves.	Minute yellowish insects.
Leaf hopper bug.	Do.	Suck juice from tender parts.	*Eurybrachis tomentosa*, F. (Fulgorid—bug).	Bugs can be easily collected.	An active green and red bug.
			SOME USEFUL TREES OF THE PLAINS.		
			NIM (*Azadarichta indica*).		
Nim scale ..	Coimbatore, Bellary and Krishna.	Colonies cover the whole tree and cause severe blight.	*Pulvinaria maxima*, Gr. Other scales noted are *Lepidosaphes meliae*, Gr., and *Parlatoria camelliae*, C. (Coccid—scales).	Prune badly infested branches and spray contact insecticide.	This *Pulvinaria* is a specific pest of this tree; also found to a small extent on Cotton and Jatropa. Pl. II and XIII, Coccid bulletin.

Shootbug ..	Coimbatore.. ..	Suck the sap from shoots which dry up often.	*Helopeltis antonii*, S. (Capsid—bug).	Collect the bugs with net if possible.	The frequent drying up of nim shoots is believed to be due to the damage by this bug. This has to be definitely confirmed. See under "Tea."
			BABUL (*Acacia arabica*).		
Babul scale ..	Coimbatore.. ..	Colonies cover tender shoots and stem and suck sap.	*Anomalococcus indicus*, Gr. (Coccid—scales.)	Prune badly infested branches; often checked effectively by a predator moth (*Eublemma*).	Very common in and around Coimbatore and visited by the common black ant Pl. XIX, Coccid bulletin.
Hairy caterpillar.	Coimbatore and Ceded districts.	Feeding on the foliage and bark.	The chief species found are—*Taragama siva*, Lef. (Lasiocampid—moth). *Euproctis lunata*, W. (Lymantrid—moth).	Prune badly affected branches containing numerous caterpillars and spray arsenate if necessary.	*Taragama* is a stout elongated caterpillar with the colour of the bark and fully clothed with irritating hairs. *Euproctis* appears as
		The bag worm *Clania crameri*, W. also is sometimes found.		a very serious pest in certain years and completely defoliates babul trees in many places.	
			PUNGAM (*Pongamia glabra*).		
Plant bugs ..	Mysore, Malabar and Coimbatore.	Swarms of the bug settle on tender shoots and suck sap.	*Coptosoma cribraria and Cyclopelta siccifolia*. (Pentatomid—bugs).	Same remedies as when the insect is found on lab-lab.	*See* under "Lab-lab" and "Erythrina" above. Sometimes whole trees are covered by millions of this bug.
Fruit gallfly ..	Coimbatore, Mysore and Ceded districts.	The fruit pods are bored and turned into round galls.	*Aspondylia pongamiae*, F. (Cecidomiyaiad—fly.)	Collecting and destroying the early galls is the only practicable remedy that can be employed.	....
Leaf caterpillars.	Malabar and Coimbatore.	Feeding on the leaf exposed in folds or mining into leaf tissue.	*Parata alexis*, F. (Hesperid—butterfly). A leaf miner is also found.	The leaf folds containing caterpillars could be easily collected with the caterpillars in them.	Not common pests. The leaf miner is often bad in Malabar.
Pod caterpillar.	Madras	Boring into pods ..	*Lamoria* sp. (Pyralid—moth.)	First attacked fruit pods may be destroyed.	Found once only in Madras.

I. Insects affecting important cultivated plants in South India—*cont.*

Insect.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
			SOME USEFUL TREES OF THE PLAINS—*cont.*		
			PORTIA (*Thespesia populnea*).		
Black scale ..	All over South India.	Cover the tender shoots and leaves and suck juice.	*Saissetia nigra*, N. (Coccid-scale).	Same remedy as for the black scale on garden plants.	Avenue trees very often suffer badly from the "black scale."
			TEAK (*Tectona grandis*).		
Leaf roller ..	All over South India, chiefly West Coast.	Feeding on leaves inside rolls.	*Hybloea puera* C. (Noctuid—moth).	Control sometimes difficult in bad cases. Caterpillars may be handpicked and the foliage sprayed with lead arsenate.	Fig. 258, S.S.I. The insect is sometimes found on *Millingtonia* and *Bigonia* plants also.
eak defoliator ..	All over South India, chiefly West Coast.	Defoliating the plants ..	*Pyrausta machaeralis*, W. (Pyralid—moth).	Control sometimes difficult in bad attacks. Caterpillars may be handpicked and the foliage sprayed with lead arsenate.	Fig. 319, S.S.I. A yellowish brown moth.
Teak gall ..	Tinnevelly ..	Producing ball-like galls on the branches.	Unidentified *cynipid* (wasp).	Collect and destroy early forming galls.	So far found only in Tinnevelly forests.
Teak borer ..	Malabar	Grub boring into the stems.	*Psiloptera fastuosa*, F. (Buprestid—beetle).	Infested branches may be cut and the beetles may be caught easily.	Shining green and blue jewel beetle. Fig. 140, S.S.I.
Mealy bug ..	Do.	Covering shoots ..	*Phenacoccus hirsutus*, G.	Clip badly infested shoots.	Cocc. Bull. Pl. XXV., 2.
			CASUARINA (*Casuarina equisetifolia*).		
Bark caterpillar.	Ganjam, Godavari and Kistna.	Caterpillar girdling bark and often causing severe damage.	*Arbela tetraonis*, M. (Arbelid—moth).	See under "Citrus" ..	This insect attacks many trees.

Stem borers ..	**All along Coromandel coast.**	**Grubs bore into the stem and often kill the young plants.**	***Caelosterna scabrator*, F., also *C. spinator*, F., and *Heresium simplex*, G. (Cerambycid—beetles).**	**Sometimes the first is a bad pest and difficult to deal with. Same remedies as for mango and citrus stem borer beetles.**	**Reported now and then from Coromandel tracts. Fig. 181, S.S.I.**
Ground cricket.	**Nellore**	**Damaging seedlings** ..	***Brachytrypes portentosus*, L. (Gryllid—cricket).**	**Collect the cricket; hoe the soil well to kill these underground pests and if necessary irrigate with poisoned water.**	**Fig. 430, S.S.I.**
			RUBBER.		
Stem borer ..	Anamalais and Western Ghats.	Grub bores into stem ..	*Batocera rubus*, L. (Cerambycid—beetle).	Reported once attacking rubber stump in the Western Ghats. Probably a minor pest.	*See* under "Mango."
Bark beetles ..	**Western Ghats** ..	The small beetles and grubs bore into bark and interfere with latex flow.	*Xyleborusbiporus* S., and allied species (Scolytid—beetles).	Prune badly infested branches and scrape loose bark.	Minute dark brown beetles. Status doubtful.
			RAIN TREE (*Pithecolobium saman*).		
Mealy bug ..	Coimbatore ..	Cover the shoots with mealy masses.	*Phenacoccus iceryoides*, G. (Coccid—mealy bug).	Prune badly infested branches and spray contact insecticide.	Pl. XXV, Fig. 1, Coccid bulletin.
Scales ..	Do. ..	Cover shoots and stem and suck juice.	*Aspidiotus spp.* and *Aspidoproctus xyliae*, Gr. (Coccid—scale insects.	Do.	Pl. XXX, Coccid bulletin.
			BANYAN TREE.		
			(*See* under Fig. Most of the pests are same for all Ficus *spp.*).		
			ASOKA, POINCIANA, ETC. (*Avenue trees*).		
Stem borer ..	Coimbatore. Chingleput, etc.	Boring into the stem or between stem and bark in galleries of wood dust.	*Arbela tetraonis*, M. (Arbelid—moth).	The tree bark to be thoroughly scraped and the same treatment to be adopted as when the insect is found on fruit trees.	*See* under "Citrus" above, sometimes very bad on avenue trees of different kinds.

I.—Insects affecting important cultivated plants in South India—*cont.*

Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
		SOME USEFUL TREES OF THE PLAINS—cont.			
		PALAS (*Butea frondosa*).			
The leaf miner beetle.	Mysore, Malabar and Coimbatore.	The grub mines into leaf and causes blister spots on leaves; occasionally serious.	*Trachys bicolor*, K. (Buprestid—beetle).	Cut and burn badly infested leaves.	A small bluish black beetle.
Leaf bug	Coimbatore ..	Hundreds swarm on tender leaves, suck juice, and turn them pale.	*Coptosoma ostensum*, Dt. (Pentatomid—bug).	Clip badly infested leaves.	A lady-bird beetle is found as predator on this.

II.—Insect pests of stored products.

The rice weevil.	All over the Presidency.	Adults feed on stored grains like rice, wheat, cholam, maize, etc. Grubs bore into the grains and devour the contents. Powdery material is thrown out of the bag in patches.	*Sitophilus oryzae*, L. (*Curculionidae*).	The following measures can be adopted for the control of the pests, in cases where entire grains like maize, wheat, cholam, paddy, etc., are concerned. The godowns should be thoroughly cleaned and disinfected either with BHC D. 024 or D. 034 or DDT. 10 per cent (Geigy 33) or Gammexane smoke. The grains should be well dried before storing and the bags themselves stacked with adequate dunnage, alleyways and gangways. Infestation can be prevented by dusting the surface of the bags with DDT 10 per cent (Geigy 33) or BHC D. 024 or D.034 dust. If the stocks are heavily infested, they can be fumigated with calcium cyanide at 3 to 4 lb. per 1,000 c.ft. or Killoptera at 20 lb. per 1,000 c.ft. for 24 hours. Care should be taken to eliminate all traces of HCN before issuing the grains for consumption. Neither fumigation with calcium cyanide nor the application of the dusts should be adopted in the case of husked rice, flour, oil seeds, etc. Killoptera and Pyrethrum products may be used for fumigation and dusting respectively.	Small brownish black weevil about ⅛" in length with a cylindrical body and curved beak.

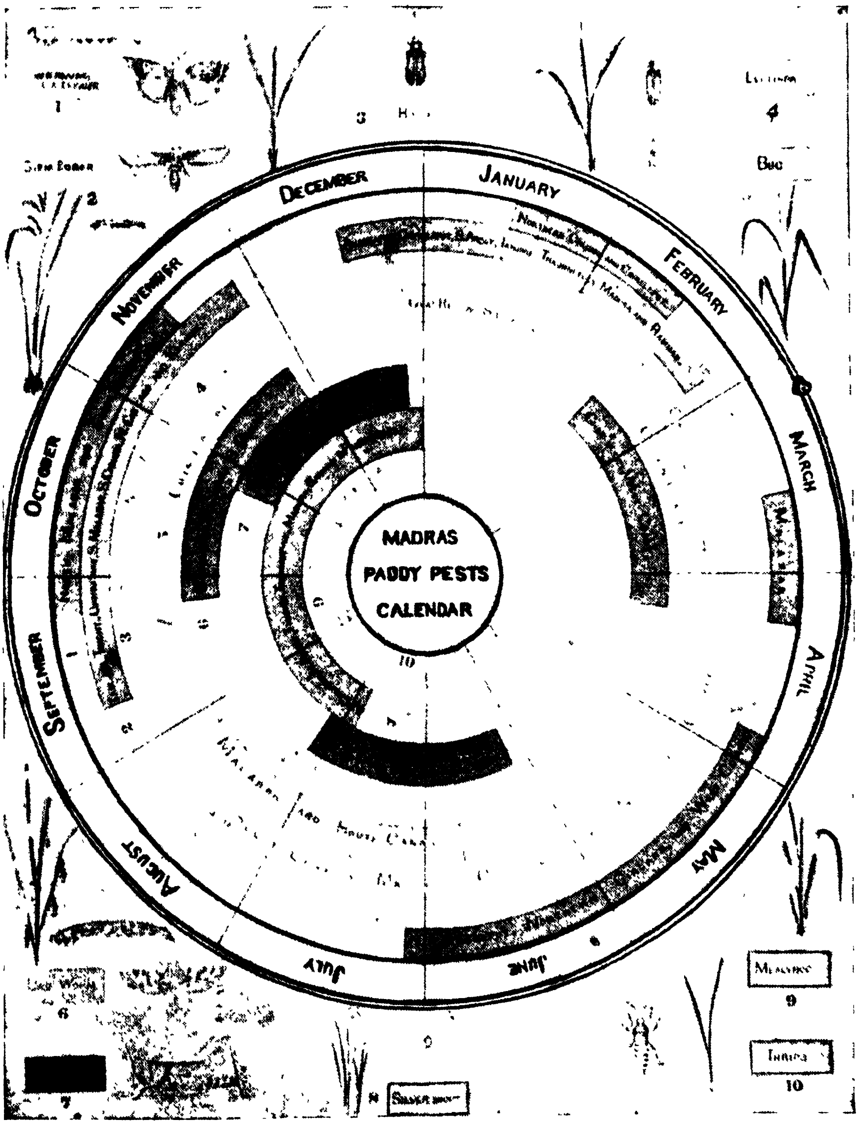
The paddy borer beetle.	Do.	Adults feed on stored grains like rice, wheat, cholam, maize, etc., Grubs bore into the grains and devour the contents. Circular patches of powder are seen here and there on the bags with a pin spot in the middle.	*Rhizopertha dominica*, Fb. (*Bostrychidae*).	Do.	Dark brown, 1/8" in length with a stout globular head.
The redgrain beetle or the flour beetle.	Do.	Adults and grubs feed on the broken grains and flour and impart an unpleasant smell to the infested material. Powdery material is thrown out continuously from the bag.	*Tribolium castaneum*. Hbst. (*Tenebrionidae*).	Do.	Elongate, flattish red beetle, 1/8" in length.
The sawtoothed grain beetle.	Do.	A minor pest found on a variety of stored products.	*Oryzaephilus surinamensis*, L. *Cucujidae*.	Do.	Reddish brown beetle more slender and active than Tribolium with saw-tooth like projections on each side of the thorax.
The khapra bettle.	Mainly distributed in the Punjab and Sind. Recently found in this Presidency.	Feed on wheat and pulses. The presence of cast skins on the bags and round about is a diagnostic symptom of the infestation.	*Trogoderma granaria*, Ev. (*Dermistidae*).	Do.	Shiny black, 1/2" long, head distinctly seperated from the body by a narrow thorax.
The flatgrain beetle.	All over the Presidency.	Feed on grains and grain products.	*Laemopholœus minutus* Oliv. (*Cucujidae*).	Do.	Tiny flat beetle about 1/16" with long filiform antennae as long as the body.
The pulse beetles.	Do.	Various species of this beetle attack pulses of all kinds rendering them damp and matty.	*Bruchus theobromae*, L. *Bruchus phaseoli*, G. *Bruchus analis*, F. (Bruchidae).	Do.	Adults about 1/4" in length, heart-shaped and dark. brown or speckled bodies.

II.—Insect pests of stored products.—*cont.*

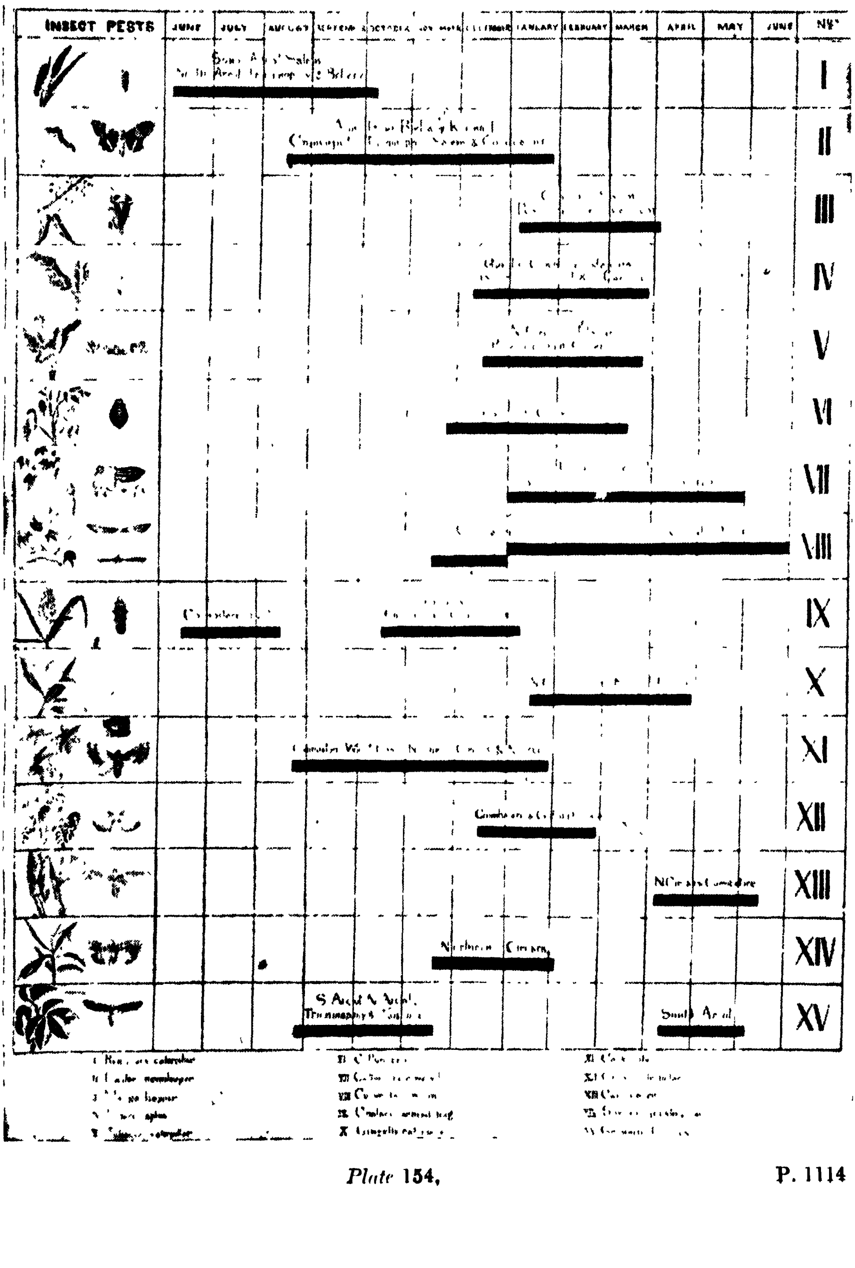
Insects.	*Distribution (in pest form in case of important insects).*	*Nature of injury done to plant.*	*Scientific name and classification.*	*Suggestions for control, if any.*	*Remarks.*
The tobacco borer beetle.	All over the Presidency.	The grubs bore into cigars, tobacco, ginger, turmeric, chillies, etc., thus ruining the quality.	*Lasioderma serricorne*, Fb. (Ptinidae).	The following measures can be adopted for the control of the pests, in cases where entire grains like maize, wheat, cholam, paddy, etc., are concerned. The godowns should be throughly cleaned and disinfected either with BHC D. 024 or DDT. 10 per cent (Geigy 33) or Gammeane smoke. The grains should be well dried before storing and the bags themselves stacked with adequate dunnage, alleyways and gangways. Infestation can be prevented by dusting the surface of the bags with DDT 10 per cent (Geigy 33) or BHC D. 024 or D. 034 dust. If the stocks are heavily, infested they can be fumigated with calcium cyanide at 3 to 4 lb. per 1,000 c.ft. or Killoptera at 20 lb. per 1,000 c ft. for 24 hours. Care should be taken to eliminate all traces of HCN before issuing the grains for consumption. Neither fumigation with calcium cyanide nor the application of the dust should be adopted in the case of husked rice, flour, oil seeds, etc. Killoptera and Pyrethrum products may be used for fumigation and dusting respectively.	Small-red beetle about 1/16″ in length.
The tamarind beetle.	Do.	Grubs bore into preserved tamarind seeds.	*Caryoborus gonogra*, Fb. (*Bruchidae*).	Do.	Dirty grey beetle.
The paddy moth.	Do.	Larvae bore into the grains, web them toget her and turn them into chaff.	*Sitotroga cerealella*, Oliv. (*Geleci hidae*).	Do.	Yellowish, shining moths with fringed wings.
The rice moth.	Do.	The grains are webbed together into tubular galleries by the larva Oocoons are seen on the seams of the bags.	*Corcyra cephalonica*, St. (*Pyralidae*).	Do.	Greyish, brown moth.
The Indian meal moth.	Do.	The grains are webbed together into tubular galleries by the larva. Cocoons are found between two bags at the line of contact.	*Plodia interpunctella*, H. (*Pyralidae*).	Do.	Grey moth with whitish bands across the inner half of the wings.
The fig moth ..	Do.	Infest groundnut kernels tunnelling the seeds and webbing them together.	*Ephestia cautella*, Walker. (*Pyralidae*).	Do.	Greyish in colour with transverse stripes on the forewings.

Besides these major pests mentioned above, a number of minor forms like the drug store beetle (*Sitodrepa panicea*, L. (*Ptinidae*), the spider beetle *Gibbium psylloides*, Cz. (*Ptinidae*), the black fungus beetle *Alphitobius piceus*, Ol. (*Tenebrionidae*), the long. headed flour beetle *Latheticus*, W., the Cadelle beetle *Tenebrioides mauritanicu* L. (*Trogostidae*), etc., are found to attack various kinds of stored products. The control measures have to be judiciously adopted according to the nature of the material infested.

Calendar No. 1.



CALENDAR OF IMPORTANT PESTS OF CHIEF CROPS OTHER THAN PADDY



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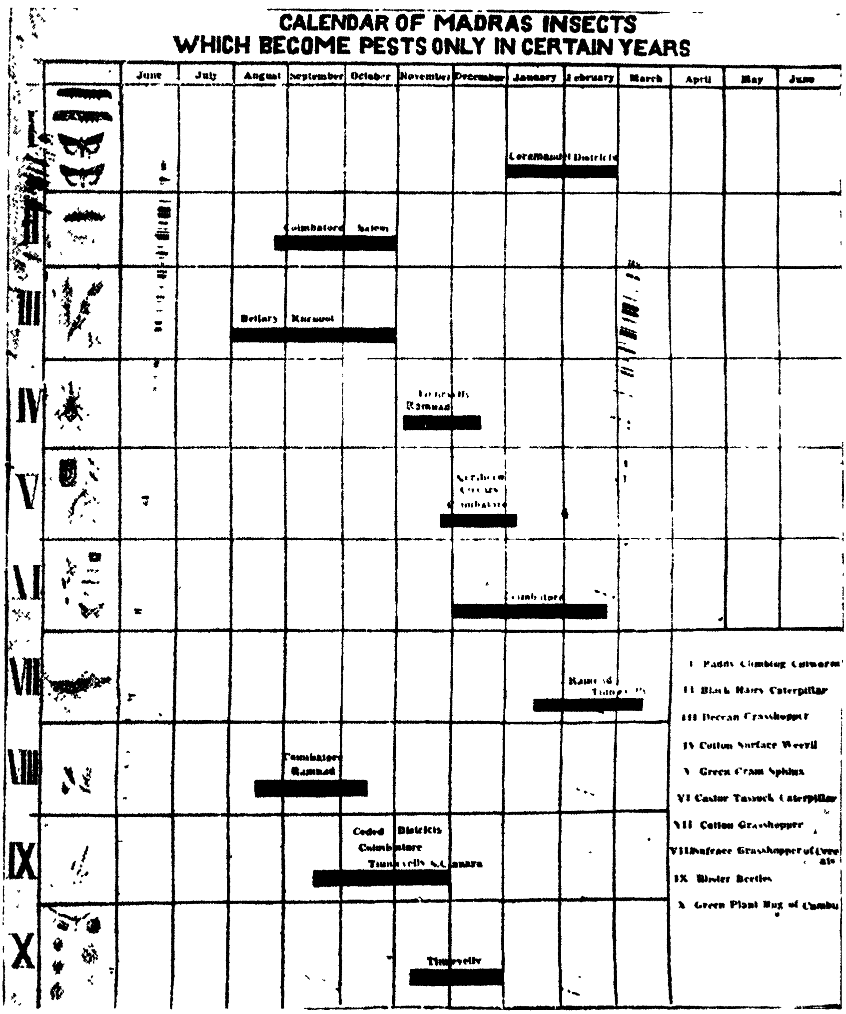


Plate 155.

CHAPTER 23.

CROP DISEASES.

Early work—the palmyra bud-rot and the sugarcane red-rot—Crop diseases caused by fungi, their life histories, damage caused, control measures tried and results obtained, cropwar :—Rice, sorghum, ragi, bajra, setaria, paspalum, wheat, sugarcane, cotton, groundnut, redgram, horsegram, palms, arecanut, pepper, chillies, tobacco, citrus, banana, grapevine, coffee, tea—Diseases caused by viruses—sugarcane mosaic, tobacco virus, potato diseases, brinjal little leaf, bendai mosaic, papaya leaf curl, tomato and cardamum disease—Deficiency diseases, boron, zinc and copper deficiency—Diseases due to physiological causes, black heart of potato—Fungicides—Bordeaux-mixture—Lime—Sulphur, Zinc-Sulphate, lime mixture—Dry dressing of seed grains—Legislation—Pests and Diseases Acts—List of diseases of cultivated plants in South India.

Apart from insects, wild animals and rodents, plant ' diseases ' take a heavy toll of agricultural produce and rob the farmer of the fruits of his labour. A plant may become diseased owing to diverse causes which are not always easy to determine. A number of fungi, bacteria, eelworms, flowering plants and viruses are involved as casual agents of plant diseases. Furthermore, inadequate or ill-balanced supply of the plant's complex nutritional requirements, lack of suitable environmental conditions for its healthy growth in relation to the soil, air, temperature and sunshine are also factors responsible for causing diseased condition in plants. The presence of toxic substances in the soil or atmosphere also sometimes causes serious injury to plant life. To combat a plant disease successfully, the first step is to ascertain the cause of the disease. This is a difficult enough problem in itself. After ascertaining the cause, suitable methods of control which would not unduly raise the cost of crop production have to be devised. In the cases of diseases caused by the invasion of parasitic agencies, the method adopted should be such that will kill or arrest the growth of the parasite without doing any injury to the crop plant. Considering the above difficulties, it is not surprising that though crop diseases have been known to afflict mankind from the earliest times and have often been causes of severe famine in many countries, it is only in comparatively recent times, with the advancement of scientific knowledge in all directions that any progress has been made in the control of plant diseases. Though the progress has been substantial and rapid from the middle of the nineteenth century onwards, much leeway has to be made up, even in the advanced countries of the world, in regard to the problem of crop diseases.

In the Madras State, the loss caused by various diseases affecting the crop plants has been estimated to run into crores of rupees annually. Now and then, a crop disease breaks out in a virulent

form in extensive areas causing almost total destruction of the crop. Our important food crops like rice, sorghum and ragi, commercial crops like sugarcane, cotton, tobacco and groundnut, fruits, vegetable and plantation crops are all subject to the incidence of diseases, and the realisation of this fact in the early years of this century led to the organisation of the Mycology section as an important limb of the newly started agricultural department of the Madras State.

The Bud-rot disease of the Palmyra and the Red-rot disease of sugarcane were the first to receive attention and investigation of other diseases of crops was taken up subsequently. The section was started in the year 1910 with a limited staff and was strengthened gradually as needs arose. An account of the results achieved during the course of these four decades is given in the following pages.

Crop diseases caused by fungi.—Fungi are organisms belonging to the plant kingdom but unlike green plants can live only on other living organisms as *parasites*, or on organic matter as *saprophytes*. They lack the green colouring matter which helps the ordinary plant to build up its own complex food requirements from the carbon-dioxide present in the air and the water and salts present in the soil. Some fungi like the mushrooms are sufficiently large to be familiar to everyone but others are minute organisms and can be seen clearly only with the aid of the microscope. A few fungi are directly useful to man, as for example the edible mushrooms, the yeast which serve as fermenting agents and Ergot and Penicillium which yield valuable medicines. Others help him indirectly by aiding the decay of organic matter in the soil, a process which is essential for replenishing the fertility of the soil. But unfortunately many fungi are harmful, and are responsible for causing crop diseases. They also attack stored products. Disease-causing fungi gain entrance to the plant through various means, invade its tissues and draw their sustenance from the food material built up by the plant for its own use. In some extreme cases fungi may cause the death of the entire host plant but in others they may affect only parts of the plant such as roots, stem, leaves, fruits, etc. In a few cases their presence may not show any outward symptom to appear but nevertheless the invasion of a parasitic organism invariably renders the attacked plant unthrifty, and impairs its economic usefulness.

The control of fungus diseases is effected in many ways, depending on the nature of the disease. It will be seen from the following pages, that control measures are directed mainly towards prevention rather than cure since in many cases it is not possible to check a disease once it has gained an entrance into the plant and has invaded its tissues. Treating the seed with fungicides, application of chemicals to the foliage, removal and destruction of infected material, sterilisation of the soil, are some of the methods now adopted to control plant diseases. Where these methods are not feasible and in addition to these, recourse is also had to the selection and breeding of disease resistant varieties of cultivated plants.

Diseases of crops.

ORYZA SATIVA (*Rice*).

A number of diseases caused by fungi occur in South India. Of these some are of very great economic importance, frequently causing heavy damage to the crop in extensive areas while others are of only minor importance, either causing negligible injury or being restricted to limited areas. The investigation of the major diseases of rice has been an important item of the work of the Mycology section from the very beginning and an account of the work done on the diseases recorded in South India is given hereunder :—

BLAST—Piricularia oryzae (cavara).—Owing to its wide distribution, frequency of occurrence and destructiveness, the disease known as 'Blast' is by far the most important disease in South India. It was first recorded in the Tanjore district in the year 1918 and was noticed to have been responsible for considerable damage to the crop in the Papanasam taluk. Since then the disease has been noticed in all the rice-growing districts of the State but the damage caused by it has been particularly severe, besides Tanjore, in the districts of Visakhapatnam, Nellore, Chittoor, Coimbatore, Chingleput, Madurai, Tiruchirappalli and Tirunelveli. The disease occurs in a virulent form and under certain favourable weather conditions takes a heavy toll. In bad years losses extending up to 90 per cent of the crop have been recorded in parts of Tanjore and Nellore districts.

The disease is caused by a fungus *Piricularia oryzæ* which attacks the crops in all stages of growth, that is from the seedling to the heading stages. The fungus invades the leaves, culm and the panicle. In the nursery, affected plants wither and die. In the transplanted crop, characteristic spindle-shaped necrotic lesions appear on the leaf. These have a dark brown margin and a greyish centre. As the disease develops the lesions enlarge and coalesce and the leaf turns brown. When the culm is attacked the nodes become blackened and the culms often break at the joints. By far, the greatest amount of damage occurs when the neck of the panicle is attacked when the crop is in ears. The development of the grain is arrested resulting in light ears and often the panicle breaks at the joint.

Losses are proportional to the intensity of infection which in turn is governed by the degree of susceptibility of the variety and the weather conditions that prevail during the period, and also the nitrogen status of the soil.

Between 1919 and 1924 pathogenicity trials were conducted with *Piricularia* occurring on *Ellusine coracana* (Ragi), *Setaria italica* (Tenai), *Triticum* sp. (wheat), *Oryza sativa* (Rice) and *Panicum repens*. The fungi occurring on these hosts, though morphologically similar were shown to differ in their pathogenicity.

reactions. During this period spraying with fungicides and seed treatment were tried as control measures, without any conclusive results.

During 1924–25 varietal resistance trials were carried out. It was noticed that there was a wide variation in the susceptibility of different varieties. Varieties '*Korangu Samba*', '*Kattai Samba*' and '*Kattai Sambalai*' (which appear to be synonyms of the same variety) were observed to be the worst affected. In the succeeding years these observations were confirmed. Among the early varieties noticed to show a high degree of resistance was *GEB* 24. This variety has since been shown to be susceptible under certain conditions but on account of its early maturity normally escapes the disease in Coimbatore and Tanjore. In subsequent years (1926–43) a large number of varieties released by the Paddy Specialist were tested for their relative resistence. Of these Co. 4 was found to be consistently resistant to blast to a greater degree than other varieties and this variety has since been used as a parent for the evolution of resistant varieties by hybridization.

Owing to the importance of the disease in the State a separate scheme for the investigation of Blast and Foot-rot diseases of rice was sanctioned in 1943 by the Indian Council of Agricultural Research and has been in existence since then.

The work carried out under the scheme is summarized below :—

(1) *Varietal resistance.*—Testing of various varieties of rice to blast resistance formed a major part of the work. Three hundred and three cultures of rice were tested up to the end of 1949. Of these 35 were found to be highly resistant consistently for a number of years under different seasonal conditions. Of these, 12 were finally selected and grown in trial plots in the districts of Tanjore, Tiruchirapalli and Madurai to test their suitability to different tracts. Two of these cultures (Hybrid ADT 10 × Co 4), Co 25 and Co 26, have been found to possess other desirable qualities as well and have been released as blast resistant strains for distribution in Tanjore, Tiruchirapalli and Madurai districts. These are long duration strains and are not suitable in tracts like Chittoor and Chingleput where this disease is an important limiting factor in crop production. Work is in progress to test the hybrid selections of the short duration types evolved by the Paddy Specialist.

Varieties obtained from other States in India have all proved to be susceptible to blast when tested in the field. In 1949–50 varietal resistance experiments were duplicated at Buchireddipalem.

(2) *Manurial experiments.*—Earlier work in 1926–29 had shown that heavy applications of nitrogenous manures tended to increase the susceptibility of the rice plant to blast. The results of the manurial experiments carried out under the scheme showed that in susceptible varieties the application of increasing levels of nitrogen beyond a minimum tended to increase the incidence of the

disease. Over a basal dressing of 5,000 lb. of green leaf, an application of 20 lb. of nitrogen per acre either as ammonium sulphate or groundnut cake does not increase the susceptibility of the plant to the disease under the conditions of the experiment in the Central Farm, Coimbatore. But the application of 40 to 60 lb. proportionately increases the incidence and the yield is adversely affected, the increase due to the application of the manure being neutralised by the heavier incidence of the disease. In the absence of the disease, as happens in years unfavourable for its spread, however, the yield is proportional to the amount of nitrogen applied. In resistant varieties (Co 4) the yield is proportional to the increasing levels of nitrogen and under conditions of the experiment an application of 80 lb. of nitrogen did not result in increased incidence.

(3) *Factors responsible for disease resistance.*—Examination of the leaf structures of resistant and susceptible varieties showed that blast resistance was positively correlated with the number of silicated epidermal cells distributed per unit area.

(4) *Conditions favouring disease development.*—A high relative humidity and a low night temperature resulting in dewy mornings, were found to be conditions favouring disease development.

(5) *Alternative hosts of the causal fungus.*—Pathogenicity experiments with the fungus isolated from the following grasses showed that they are alternative hosts of *P. oryzæ*. (1) *Panicum repens*, (2) *Digitaria marginata*, (3) *Dinebra retroflexa*, and (4) *Leersia hexandra*. Of these *Digitaria marginata* has been recorded as an alternative host to this species in earlier years. The grass *Panicum repens* has a wide distribution and would appear to carry the disease over from one season to another.

Foot-rot—Gibberella fujikuroi (Saw) Wr.—(Fusarium moniliforme Sheldon var. (majus)—*Distribution of the disease and history of investigations.*—The foot-rot disease may be considered to be next in importance to the blast disease in South India. The disease has been noticed to occur in the Godavari delta and the districts of Coimbatore, Madurai and Chingleput on a scale which results in considerable loss of crop in the nursery. The investigation of the disease was started in 1930 and considerable progress in the study of the disease was made between the years 1930 and 1935. The fungus responsible for the disease was identified as *Fusarium moniliforme var. majus*, and studies relating to the physiology and morphology of the organism were pursued. Various methods of control against the disease were tried and it was found that the disease being seed-borne could be controlled by seed treatment. Copper-sulphate solution of two per cent strength gave promising results, but was found to adversely affect the germination. The newly introduced organo-mercury compounds like Granosan, Ceresan, etc., were found to be extremely effective in controlling the disease.

Investigation of the disease was pursued from 1943 onwards, under the special scheme of the Indian Council of Agricultural Research for paddy diseases. Studies relating to varietal resistance and fungicidal treatments were carried out.

Nature of the disease.—Affected seedlings die out in large numbers. In seedlings characteristic symptoms of the disease, viz., abnormal elongation and etiolation are noticed. In the transplanted crop the affected plants grow thin and pale and shoot up conspicuously above the level of other healthy plants. The plants usually die out before flowering and when occasionally the ear is formed the grains are unfilled.

The disease causes the greatest damage in the nursery and the inadequate supply of seedlings for transplanting results in sparsely planted fields with consequent reduction in the yield. The death of plants after transplanting also results in reduced yield.

Control measures—(1) *Varietal resistance.*—The relative resistance of a large number of varieties was evaluated by field experiments. The varieties of paddy tested showed a wide variation in their susceptibility to foot-rot. Two of them, GEB 24, and PTB 7, showed a very high degree of resistance consistently over a period of years. CO 10, CO 13, and CO 11 were highly susceptible. The other varieties tested were intermediate between the two extremes.

(2) *Fungicidal treatment.*—Among the various fungicides tested the following organo-mercury compounds were found to be the most effective: (1) Ceresan (Tillantin R), (2) Agrosan GN, (3) Aagrano, (4) Atiran, and (5) Nomersan. Other fungicides like Dithane, Perenox, Merfusan, etc., were not so effective. The optimum dosage of the fungicides was found to be one gram of fungicide for a pound of seed (or 1 lb. of fungicide for 450 lb. of seed), though a dosage up to two grams per pound of Ceresan and Agrosan GN could be used without adversely affecting germination.

During the years 1945–49 large scale demonstrations of the method of seed treatment for the control of the disease were carried out in a selected village in the Gobichettipalayam taluk of Coimbatore district and every year nearly 1,000 acres of rice were sown to treated seed. This helped to popularise the method in the area among the cultivators who are now taking up the treatment of their own accord. The cost of the treatment as per the current prices of the fungicides does not exceed annas four per acre.

(3) *Mode of infection.*—Experiments carried out at Coimbatore in 1945–46 showed that the fungus infects the plant mostly through spores borne on the seed. The chance of infection through the soil is very limited under swamp conditions. Secondary infection in the field is brought about by air borne infection of the shoots and the panicle.

(4) *Physiological races of the fungus.*—Isolates of the fungus from different localities exhibited varying degrees of virulence in

affecting paddy seedlings under the same conditions. An isolate from material collected at Erode (Coimbatore district) showed greater virulence than isolates from other localities.

The fungus has been isolated from *Sorghum vulgare* (cholam), *Pennisetum typhoides* (cumbu) and *Saccharum officinarum* (sugarcane) but the isolates differ in their pathogenicity reactions.

Helminthosporiose.—This disease is prevalent throughout the State. Though, as a rule, it is not, under South Indian conditions, responsible for as much damage to the crop as the blast or foot-rot disease, but occasionally the disease gains the upper hand, and loss of crop occurs. The disease was first noticed in 1920–21 and a detailed investigation on various aspects was initiated.

Nature of the disease.—The disease is characterised by the formation of dark brown or reddish spots on the surface of the leaves, rectangular or oval in shape, the lesions being confined to the space between parallel veins. The leaf sheath is also invaded and in cases of extreme severity of the disease the neck of the panicle is attacked. When the sheath of the boot is attacked, the emergence of the panicle is interfered with and the plant fails to put forth the ear. The glumes are also attacked and the fungus invades the interior of the developing grain.

Results of the investigations.—Investigations carried out between the years 1923–24, showed that the disease is seed-borne and primary infection could be controlled by seed treatment. As the fungus invades the interior of the grain, hot water treatment gave better control than fungicidal treatments. Secondary infection is spread through air-borne spores and control is not feasible on a large scale.

Studies on the morphology and physiology of the fungus were pursued and pathogenicity trials with isolates from different hosts carried out. In 1938–39, the study of two isolates from rice revealed the fact that two distinct species of *Helminthosporium* were involved viz., *H. Oryzæ* and *H. tetramera.*

In the succeeding years further studies on the physiology, morphology and pathogenicity of different isolates of *Helminthosporium* were made. It was found that the fungus causing the disease in paddy was different from those isolated from ragi or wheat.

Varietal resistance studies carried out during the period showed that none of the varieties tried was highly resistant, though a wide variation in susceptibility was noticed. Heavy seed infection results in seedling blight which is favoured by lack of sufficient water-supply. This phase of the disease could be controlled by seed treatment with (1) hot water at 55° C. for 10 minutes or (2) organo-mercury compounds like Ceresan or Agrosan at the rate of one gram per pound of seed. The former method is, however, not recommended as it involves the risk of the seed losing its viability, if proper care is not exercised in maintaining correct temperature.

MINOR DISEASES OF RICE.

STEM ROT OR SCLEROTIAL DISEASE—*Leptosphæria salvinii Catt* (Sclerotium oryzœ Catt) Helminthosperium sigmoideum Cav.

Among the minor diseases of rice recorded in South India, stem-rot occasionally assumes dangerous proportions and is responsible for some amount of damage. Though the disease has been recorded from almost all the rice growing areas of the State the disease has been noticed to occur in a severe form only in the Tanjore and Krishna districts. In Tanjore severe damage to the *Ottadam* crop was noticed in the Shiyali and Nannilam taluks in 1948.

Nature of disease.—The disease is characterized by rotting of the stem at the base which results in the leaves turning yellow. The disease occurs only in the transplanted crop and manifests itself when the crop reaches maturity. In cases of severe attack. the affected plants lodge prematurely and in less severe cases the development of the ear is retarded and the ear-head fails to emerge from the boot.

Results of investigations.—The disease was found to be associated with a fungus which forms abundant small sclerotia on the culms. Studies of the fungus in the laboratory revealed that it produced the conidial stage, *Helminthosporium sigmoideum* which is identical with the organism causing the stem-rot disease in other countries, and inoculation trials with the sclerotia and conidia of the fungus were successful in inducing the disease on inoculated plants grown in pots.

Control measures.—The Sclerotial disease of rice is difficult to control. Methods suggested by workers in other countries are, burning the infected stubble ' in situ ' to prevent the perpetuation of the disease in the field and periodical draining of the water from infected fields and allowing just sufficient moisture in the field to keep the plants growing. The latter method was found to be feasible only in limited areas in the Tanjore district as draining off water from infected fields involved the risk of the spread of infection to other fields and the drying up of the fields resulted in their being over-run by weeds.

False smut—Ustilaginoidea virens.—The disease attacks stray grains in the panicle. The ovary is " transformed into a large velvety green mass which may be twice the diameter of the normal grain." The plant as a whole is unaffected. The disease has been noticed in all the rice growing tracts in the State but has not been known to cause any appreciable damage. There is a belief among South Indian cultivators that the presence of the disease is indicative of a bumper crop. This, however, does not appear to be correct as the disease appears year after year on a small scale in almost every field in the Godavari delta during the main season. Detailed investigation of the disease has not been carried out. The fungus was brought into pure cultures and inoculation trials

were carried out, but inoculated plants failed to take the disease and the mode of infection yet remains to be investigated.

"*Oodhu-bathi*" *disease* (Balansia oryzæ—Ephelis oryzæ).—The disease is of limited economic importance. It was first recorded in 1917 and has been noticed to occur in Coimbatore and Madurai districts causing upto one or two per cent damage. The fungus causing the disease was brought into pure culture. Inoculation trials were not successful in infecting healthy plants.

A similar fungus (*Ephelis*) was recorded on the following grasses: (1) *Echinochloa crusgalli*, (2) *E. stagnina*; *Balansia* sp. found on *Urochloa panicoides* would also appear to be similar to the fungus.

Detailed investigation of the disease was not pursued, but experiments were carried out in 1944 and 1945 to find out if seed treatments with organo-mercury compounds like Ceresan and Agrosan would be effective in controlling the disease. No conclusive results were obtained.

Root-rot (Pythium *sp.*).—A root-rot disease has been noticed to occur in various parts of the State particularly in Malabar and Tanjore. A species of *Pythium* is associated with it. Affected plants wilt all of a sudden and the base of the stem becomes soft and rotten. The fungus was isolated from affected plants and brought into pure culture. The disease was found to be controlled by the application of one per cent Bordeaux mixture in pot culture experiments. Application of a balanced manure reduces incidence of the disease. Extensive trials on a field scale have not been carried out as the disease is of very minor importance and the damage caused quite negligible.

SORGHUM VULGARE (*Cholam*, *Jonna*).

(1) *Grain smut* (Sphacelotheca sorghi).—This is the most important disease affecting this crop. It was first recorded from Coimbatore and Tirunelveli. But since then it has been observed to be prevalent in all the districts where sorghum is grown. In some years losses of ten to twenty per cent of the yield have been recorded. The seed-borne nature of the infection was established. Different methods of seed treatment were tried. At first seed disinfection by steeping in 2 per cent copper sulphate solution was advocated. Further experiments showed that dry dressing with powdered sulphur was easier and equally effective and this has been recommended in later years. It was found that sulphur diluted with equal quantities of inert matter like china clay was as effective as pure sulphur in controlling the smut. The sulphur necessary for seed treatment was made available to the ryots in packets kept for sale at the taluk depots. Over 60 tons of sulphur have been thus distributed. This treatment costs only three pies per acre. During 1949–50, 236,000 acres were sown with treated seed. The methods advocated in Burma and by Dr. Luthra, viz., soaking the

seeds in water and drying them in the shade or sun, respectively, were compared with sulphur treatment but were found to be less effective.

(2) *Loose smut* (Sphacelotheca cruenta).—This resembles the grain smut in general except for minor details. It has been recorded from Salem, Coimbatore and Madurai. The control measures adopted for grain smut are equally effective against this disease also.

(3) *Head smut* (Sphacelotheca reiliana).—This smut is of sporadic occurrence. It has been recorded from many of the districts where sorghum is grown. But the loss caused by this disease does not amount to much, as the incidence is not extensive. The entire inflorescence is transformed into a sorus covered by an evanescent whitish membrane. On the rupture of this membrane a black mass of spores mixed with fibres is exposed. Sometimes sori develop on leaves also.

The spores when kept for germination exhibit only limited sprouting. About six to ten per cent of the spores germinate. But the viability extends for over a year, a few spores germinating at a time. Experiments have shown that infection is through the soil. The spores that are shed in the soil remain viable for over two seasons and infect the young plants. The symptom becomes evident when ears are formed. Seed dressing with sulphur has no effect in preventing infection as the pathogen is not seed borne. Eradication of the smutted heads will go a long way in reducing the infection in succeeding years.

(4) *Long smut* (Tolyposporium ehrenbergii).—This is a minor disease and is usually found only in the summer crop of sorghum. It has been observed in many of the southern districts. A few grains in an ear become transformed into long whitish sori about an inch or more in length. On rupturing of the sori, black masses of spores are seen. For a long time the method of infection remained obscure. Experiments conducted in 1949 have shown that the infection is air borne. When the ears while still enclosed inside the boot leaf, are inoculated with spore suspension infection results. The spores have been found to remain viable for over a year.

(5) *Downy mildew or leaf shredding disease* (Sclerospora sorghi)—This disease has been observed in all the districts. The fodder sorghum crops exhibit greater incidence of this disease. It has also been observed that there is more of the disease in rainy seasons. The disease exhibits varying symptoms according to the stage of growth of the plant. In most cases ears do not develop. Large numbers of oospores develop in the shredded leaves. It has been established that when pieces of leaves containing spores are mixed with the soil in pots and then sown with cholam many of the young plants are infected. This proves that infection is soil borne. The fungus mycelium was found to be present in all parts

of the diseased plant, i.e., it becomes systemic and does not permit the full development of the host plant. Affected plants perish at different stages before flowering.

Another type of air borne secondary infection has been observed to be due to the conidia. This type is noticed in the later stages of the crop and results in the formation of yellowish stripes on the leaves. Ear development is not prevented in this case.

(6) *Rust* (Puccinia purpurea).—This is prevalent all over the State. In most cases the incidence is evident after the formation of the ears. This has led to the conception that it does not cause any loss to the crop. But the rust fungus is an obligate parasite and it must obviously affect the normal development of the host. It has been found that some varieties are sensitive to the rust.

Though the disease has been known from the early days of the department, closer study of the rust was commenced in the forties of this century only. It was found that the rust is prevalent on the grain sorghums and the wild fodder sorghums. Examination of the different species cultivated at the Millet Breeding Station, Coimbatore, has shown that all of them are parasitized by this rust. Cross-inoculation experiments showed that the rust can pass from one species to another and there is no evidence to suggest that physiologic races of this rust exist at Coimbatore. Infection experiments have also shown that the host plant can be infected by the rust even in the seedling stage. In nature a spurt of infection follows a spell of rainy weather.

The conditions favouring the germination of the urediospores and telio-spores were studied. Under laboratory conditions the urediospores do not remain viable for over three weeks. The teliospores are formed in December-January and can be made to germinate at once. The teliospores do not infect sorghum. But the search for the alternate host has not been successful. The germinating teliospores were inoculated on a number of weed plants, on which aecia had been observed, without success.

All the eleven strains of sorghum evolved by the department are susceptible to the rust. Careful examination and assessment of the intensity of infection of the different cultures grown at the Millets Breeding Station have been made for two seasons and some of them have exhibited a high degree of resistance to rust. These are being studied further. No control measures are known.

(7) *Anthracnose* (Colletotrichum graminicolumn).—This is an old disease recorded from most of the districts. In some years it causes intense spotting of the leaves of seedlings finally leading to the drying of the plants. This happens when prolonged rainy weather coincides with the initial stages of growth. More often it causes spots on older leaves in the later stages of the crop. This fungus has several grass hosts. It is reported to affect maize also but has not been observed to do so in this State so far.

(8) *Leaf spot* (Cercospora sorghi).—This fungus infects the crop usually in the later stages. Rectangular red or brown spots

are formed on the leaves and sheaths. Sometimes the whole leaf is involved. Infection is found to be influenced by humid weather prevailing at the time of blooming. The strain of the fungus found at Coimbatore does not pass on to maize, which is also recorded as a host for this fungus. The disease is prevalent in July and from October to December. These are rainy periods.

(9) *Leaf stripe* (Helminthosporium turcicum).—This disease is prevalent in all the districts and is of minor importance.

(10) *Bacterial leaf spot* (Bacillus holci).—This leaf spot is prevalent in Coimbatore. The spots are dark purple or red and depressed, with slight oozing of fluid from the surface. In some seasons the leaves are severely affected.

(11) *Sooty blotch* (Ramulispora sorghi) :—This disease has been recently recorded from Guntur and Coimbatore. Extensive straw coloured patches develop and in affected portions black fructifications of the fungus are formed.

(12) *Sugary disease* (Sphacelia sorghi).—This disease affects the grains and is prevalent in all districts. Drops of sugary fluid are formed in the grains and these fall and bespatter the ground, forming white spots. The yield of grain is considerably reduced.

The sclerotial stage of the fungus (*Claviceps*) has been observed in Kurnool. The sclerotia are light brown and do not contain any alkaloid. All the varieties and species of sorghum grown at the Millets Breeding Station are susceptible.

The disease is usually prevalent during November to January. Rarely it occurs in July. Rain during the flowering period is favourable for the disease. Later sown crops are more affected than others. By adjustment of the sowing period the incidence of the disease can be minimized.

(13) *Twisted top* (Fusarium moniliforme).—This is a minor disease affecting a few plants in the outskirts of the field during the rainy season. The successive leaves do not unfold readily but are held together at the tips which are usually rotten. The isolate of the fungus found in the rotten portion causes the death of the seedlings also.

(14) *Mosaic* (Saccharum virus 1).—The sorghum crop is infected by the sugarcane mosaic virus. The presence of sorghum fields in the neighbourhood of sugarcane plots is a source of danger, to the latter crop.

ELEUSINE CORACANA (*Ragi, Tamida*).

(1) *Blast* (Piricularia *sp.*).—This disease was first reported in the year 1919. Since then it has been found almost every year and is prevalent in several districts. The disease is found to affect the nursery and the transplanted crop. In the nursery leaf spots are formed and in severe outbreaks the leaves dry up. In the transplanted crop the infection is found in the form of leaf spots, blackened nodes, neck infection and finger infection resulting in chaffiness of ears.

There was no correlation between the intensities of infection in the nursery and in the transplanted crop. However, there was evidence to show that high humidity and rainfall during the flowering period always resulted in increased infection. The infection was usually much less in the crops sown in November to June. Heavy ear infection was recorded in the crop sown in July or August.

Many of the cultures evolved at the Millets Breeding Station were tested for their relative resistance to blast. It was found that all of them were susceptible in varying degrees.

The disease in the nursery stage could be controlled by spraying 1 per cent Bordeaux mixture. At the time of transplanting, the tips of the leaves are clipped and the shoots dipped in Bordeaux mixture in order to destroy the pathogen and prevent it from passing on to the transplanted crop. This method costs Rs. 2–6–0 per acre. Dusting with sulphur or spraying the ears with Bordeaux mixture did not lead to any satisfactory control of the infection.

Cross inoculation experiments showed that the isolate from ragi passed on to wheat and barley but not to rice or tenai (*Setaria italica*).

(2) *Blight* (Helminthosporium nodulosum).—This disease has been recorded from Bellary and Coimbatore. It causes spots on leaves, discolouration of stem and neck and blight of fingers. The infection is found to be seed borne and the seedlings are more liable to damage. Seed treatment reduces seedling infection.

(3) *Foot rot* (Sclerotium rolfsii).—The disease was noticed in Visakhapatnam district and at Coimbatore. The basal portions of the shoot rot and the plant wilts and dries up. Sclerotia of the fungus are formed at the base of the shoot.

The cultural characters of the fungus were studied. Sclerotia gave rise to sterile sporophores when grown on onion agar especially in darkness.

(4) *Mosaic.*—The disease has been noticed off and on in the Central Farm, Coimbatore. Moottling of leaves was evident. Sap inoculation and tissue transplantation did not produce large scale infection, but one suspicious instance was evident. Seeds from diseased plants produced healthy seedlings.

PENNISETUM TYPHOIDES (*Bajra*, *Sajja*).

(1) *Rust* (Puccinia penniseti).—This disease is widespread in the State. The rust affects the crop at different stages in its growth. In some years, plants one month old are infected. More often, the rust appears before flowering. The leaves become completely covered by the sori and premature drying of leaves results.

The rust produces a large number of uredia on the leaves. A little later telia are developed. These do not burst readily but

remain covered by the epidermis. Investigation carried out in the section have resulted in the elucidation of the complete life cycle of this rust.

The urediospores do not retain viability for over a month under laboratory conditions. The incubation period extends from eight to ten days. The teliospores germinate readily on maturity, but it takes about 72 to 96 hours.

Inoculation experiments with the germinating teliospores on a number of weeds and other hosts showed that brinjal leaves are readily infected. In ten days small swellings develop. Pycnia are formed on the upper surface and later aecia appear on the lower surface. The aeciospores readily infect bajra plants. Thus the role of brinjal as an alternate host was established. This relationship was also borne out by field observations. Brinjal crops growing in the vicinity of bajra fields often exhibit the aecial stage in plenty. The three strains of bajra being distributed by the department are very susceptible. Observations made on the incidence of rust in the different cultures of bajra grown at the Millets Breeding Station revealed that some of the cultures are less affected than others.

The rust does not usually affect the elephant grass *Pennisetum purpureum*. Some of the crosses between *P. typhoides* and *P. purpureum* are not infected while others are.

(2) *Green ear* (Sclerospora graminicola).—This disease is common in many districts, and has been known from the early years. The incidence of the disease is high in low lying portions of the field. The affected plants are pale green and covered by downy white growth. The spikllets turn into leafy structures resulting in complete sterility of the ears. Some of the branches become dwarfed and bear curled and twisted masses of yellowish leaves which later turn brown. Oospores are found in these leaves. Infection is through the soil. The fungus becomes systemic. The affected plant is rendered useless to the farmer. High soil moisture favours infection.

Cross-inoculation on tenai (*Setaria italica*) and sorghum have shown that the strain is specific to bajra (*Pennisetum typhoides*) and does not pass to the others. Though there is very little morphological difference between the fungi on bajra and tenai, they are physiologically different.

(3) *Smut* (Tolyposporium penicillariae).—This disease is of minor importance. Only a few grains in an ear are infected. The affected grains swell, turn green and contain black masses of spores. Since the infection is air-borne, seed treatment is of no use. It was observed, however, that higher incidence of smut is seen in ears which have been bagged for breeding purposes.

(4) *Top rot* (Fusarium moniliforme).—This is a minor affection confined to a few plants in the outskirts of the field during rains. The leaves do not unfold readily and as in the case of sorghum the tips of the leaves rot and the fungus is always found in this portion. The same fungus is seen in sorghum and sugarcane (*Saccharum officinarum*) also.

SETARIA ITALICA (*tenai, korra*).

(1) *Smut* (Ustilago crameri).—This disease is more in evidence in the Ceded districts than in others. Investigations on this disease were started in 1917. The fungus affects the ovaries and all the grains in an ear may be destroyed. It was established that infection is seed borne and the fungus enters the plant in the seedling stage. This information was useful in devising control measures. In the earlier years steeping the grains in 2 per cent copper sulphate solution was recommended and packets of copper sulphate were distributed to the ryots. But since 1936 seed dressing with sulphur has been recommended as it is cheaper and easier. One ounce of sulphur is sufficient for treating 15 lb. of seed.

(2) *Rust* (Uromyces setariae-italicae).—This is prevalent in all the districts. The crop is liable to be infected in all stages of growth. In some years as it did in 1941, it assumes epiphytotic dimensions and results in the complete drying and destruction of the crop. The uredia and telia alone are known. It has been reported that the telial stage is not common but under South Indian conditions telia may be seen almost annually.

The urediospores are concerned in the survival of the fungus since the teliospores do not infect Setaria. The viability of the urediospores is limited in duration. Under laboratory conditions the spores do not remain viable in the host tissue for over a month. The incubation period extends to seven days.

The same rust has been found on other species of *Setaria*, viz., *S. glauca*, and *S. pallidifusca*. But the strain from one host does not infect the others, indicating that physiological specialization is present.

The various cultures of Setaria grown at the Millet Breeding Station were periodically examined to assess their relative susceptibility to rust. All the cultures are more or less susceptible and even the culture reported to be resistant by the Millets Specialist, exhibited over 50 per cent crop infection in 1948.

The incidence of the rust is influenced by the presence or absence of rain. Further, cultivation of successive crops of Setaria in the same tract helps to increase rust incidence. Early sowings escape the rust while those which come into flower during the rainy season are heavily infected.

(3) *Green ear* (Sclerospora graminicola).—This disease has been prevalent in most of the districts for a number of years. The leaves are pale and covered over by a downy growth of fungus. The

young spindle does not unfold but turns brown and becomes shredded. The spikelets develop into sterile leafy structures and no grain is formed.

The disease was found to pass on from year to year through the agency of oospores which are shed into the soil. The fungus infects the young seedlings and the hyphae spread throughout the plant. Moist soil conditions and humid weather help to increase the incidence of the disease.

Experiments have shown that when bits of leaves containing oospores are mixed with the soil before seeds are sown the seedlings are infected in the course of a month. There is physiologic specialisation in this species.

(4) *Blast* (Piricularia setariae).—The disease causes spots on the leaves but does not affect the ear or grains. It was first recorded in the year 1919 from Coimbatore.

Cross-inoculation experiments showed that the fungus on this crop does not pass on to rice or ragi but can infect wheat and barley.

Observations on the relative resistance of various varieties of Setaria showed that none was resistant.

PASPALUM SCROBICULATUM (*Varagu, varigalu*).

Smut (Sorosporium paspali).—This smut is common in Anantapur, Visakhapatnam, Tanjore, Madurai and Coimbatore. The whole inflorescence becomes converted into a sorus. In the early stages this is covered by a thin membrane which ruptures very soon exposing the black spores. Infection is seed borne.

WHEAT (*Triticum vulgare, T. dicoccum, etc.*).

1. *Black rust* (Puccinia graminis tritici).—Though wheat occupies only a small acreage in this State, the study of the rusts of this crop has assumed importance owing to the view held in some quarters that the wheat crop in this State is a source of infection to other parts of India.

The black rust is prevalent in all districts where wheat is grown. Usually the rust begins to develop from December onwards in the plains. On the Nilgiris, however, it has been observed on summer wheats also, especially on the '*vulgare*' wheats.

Surveys of rust incidence made between 1935 and 1940 revealed that the black rust is usually present on '*vulgare*' wheats and that the local '*samba*' *Triticum dicoccum* exhibited high field resistance to this rust on the Nilgiris and Palnis. With a view to control the annual outbreak of rust in peninsular India, the summer crop of wheat on the Nilgiris and Palnis was banned during the years 1943 and 1944. A survey of the wheat growing areas conducted during January to March 1944 and 1945 showed that rust

was prevalent in Coimbatore, Bellary and Guntur in spite of this ban. Furthermore black rust appeared much earlier in some of the districts in the plains than on the hills, e.g., in Coimbatore it appeared in September.

A severe epiphytotic of black rust was experienced in peninsular and upper India during the year 1946. This stimulated active search for control measures. It was again suggested at a meeting of Plant Pathologists in Delhi that another trial should be given to Dr. Mehta's theory that wheat cultivation during April-September should be banned on the Nilgiris and Palnis. However, there was opposition to this from the Madras Mycologist who stated that a clean up campaign was not practicable as, besides wheat, the rust was found on other grasses and the complete removal of all the host plants was impossible. As information on the presence of collateral hosts was lacking, it was decided to conduct a rapid survey of the South Indian hills in order to locate collateral hosts, if any. The survey showed that black rust is prevalent on two grasses, namely, *Vulpia myuros* and *Briza minor*. Besides these two grasses, others which have been reported to serve as collateral hosts of this rust grow on the hills though no actual record of the rust on these was made during the survey.

At a subsequent meeting it was again decided despite opposition that the ban should be enforced for a period of three years from 1948. This time, the whole of the State was included. The ban has been in operation for two years. However, the incidence of black rust in Coimbatore and Bellary during the months of December-February has not been reduced to any extent. On the other hand, it is interesting to note that during surveys of the incidence of black rust in the Madras State conducted by the staff of the Plant Protection Directorate, New Delhi, it has been revealed that while 100 per cent crop infection prevailed at Bellary and Coimbatore during December, there was no incidence of black rust on the Nilgiris. This is evidence enough to show that there are other foci of infection and that no useful purpose is served by banning the summer crop on the hills.

2. *Yellow rust* (Puccinia glumarum).—This rust is prevalent only on the hills. There is no record of the occurrence of yellow rust in the plains. The local 'samba' wheat (*Triticum dicoccum*) is susceptible to this rust. If infection occurs in the early stages, the damage to the crop is substantial. However, the rust does not occur every year. Besides wheat, the rust has been found to infect *Bromus catharticus*, an introduced grass, sometimes used for fodder.

3. *Brown rust* (Puccinia triticina).—This is prevalent all over the State. Both '*vulgare*' and the local *Samba* '*Dicoccum*' wheats are susceptible. The disease is, however, generally found in the later stages of the crop. Both uredial and telial stages are found. It has been reported elsewhere that the telial stage is not found in this country, but under South Indian conditions telia are formed almost every year and in plenty.

SACCHARUM OFFICINARUM (*Sugarcane*, *Karumbu*, *Cheruku*).

1. *Red rot* (Physalospora tucumanensis = Colletotrichum falcatum).—This disease is widely prevalent in many districts and was mainly responsible for the initiation of the Samalkot Agricultural Research Station in 1902. Since then it has been found to be causing heavy damage in some years to thick canes like *Vellai*, *Poovan*, *Red Mauritius*, *Fiji* B, etc., in the southern districts also.

The study of the causal fungus have revealed that there are two principal strains, a dark and a light one in the State. These two exhibit differences in their intensity of sporulation and ability to infect different varieties of sugarcane. The physiological characters of the two strains were studied. The spread of the disease is through the use of setts from affected canes. A certain amount of secondary infection takes place through the agency of spores. The organism enters through the cut ends of setts and wounds in the rind. When diseased cane material is mixed with the soil and then healthy setts planted, infection is noticed in the resulting growths.

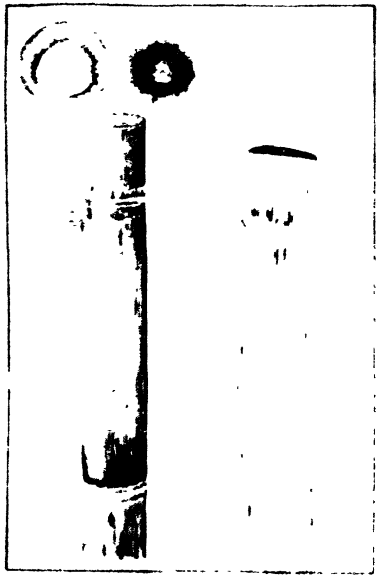
The disease causes damage in several ways. It prevents germination of buds and is thus responsible for gaps in the field. Sometimes young shoots wilt and dry up. More often, the crop nearing maturity exhibits a high incidence of the disease with withering of leaves and drying up of the shoots. Another effect of the disease is on the quality of the juice after crushing, especially when diseased and healthy canes are mixed up. Inversion takes place and the recovery of sucrose is diminished.

Experiments on the control of the disease have shown that rigid selection of setts leads to reduction in the incidence of disease. Only canes which are absolutely free from infection and which do not show any trace of reddening at the cut ends are to be used for planting purposes. Immersion of the setts in 1 per cent Bordeaux mixture before planting has a beneficial effect in preventing secondary infection. The control measures cost Rs. 7 per acre. Water-logging favours the onset of the disease. These control methods were tried with complete success at Nellikuppam in the plantations of the East India Distilleries and Sugar Factories, Ltd., and the disease was overcome.

A number of varieties of sugarcane were artificially inoculated with the fungus to note the extent of infection and the relative susceptibility of the variety in each case. Under the conditions of the experiment, all the varieties tried except CO 281 were more or less equally affected. The fungus can also infect previously wounded sorghum leaves.

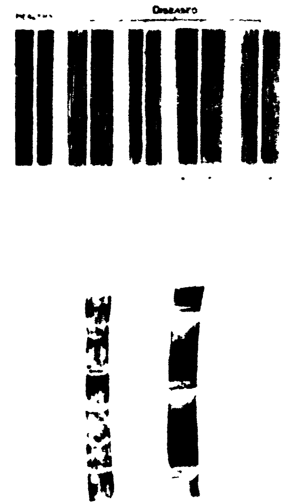
A variety of this fungus has been found to cause leaf spots on *Arundo donax*, a reed plant common in the vicinity of sugarcane plantations. The isolate from Arundo is capable of causing red-rot symptoms in sugarcane.

SUGARCANE DISEASES



Colletotrichum falcatum on Saccharum officinarum

RED-ROT



MOSAIC

scitaminea

Ustilago ~~[illegible]~~ on Saccharum officinarum

SMUT

RED-ROT AND MOSAIC CONTROLLED BY PLANTING DISEASE-FREE SETTS AND ROGUING AFFECTED CLUMPS

SMUT CONTROLLED BY CAREFUL REMOVAL AND DESTRUCTION OF AFFECTED SHOOTS

Plate 156

2. *Smut* (Ustilago scitaminea).—This disease is common throughout the State. It was originally reported to be capable of infecting only thin canes, but it has been recorded on thick canes also. In some years the disease causes heavy damage. In South Arcot and Bellary districts, the disease has been responsible for great reduction in tonnage. The practice of ratooning favours the continuance and spread of the disease. Many of the varieties are affcted. Artificial inoculations have shown that the fungus can pass on from sugarcane to *Saccharum spontaneum*. The variety CO 290 is highly susceptible while CO 419 and CO 527, are reported to be resistant to smut.

Extensive trials conducted for a period of two years on the farm of Messrs. Parry & Co., at Nellikuppam have shown that the best method of control of the smut is as follows :—The crop is examined row by row, once a fortnight from the third month after planting. All affected shoots (sori) are cut without much disturbance and the smutted shoots transferred immediately to bags made of closely woven cloth (drill). When the bag is full it is taken out of the field and immersed in a tub of boiling water for fifteen minutes to kill all the spores. The infected clumps, which are previously marked, are dug out and destroyed. At Nellikuppam this method reduced the incidence of the disease from over 50 per cent to within 1 per cent in the course of three years. The cost of treatment is about Rs. 20 per acre.

The spread of infection takes place either by the use of setts from diseased canes (primary infection) or by windblown spores (secondary infection). The spores infect the young buds. It takes nearly two months for the symptoms to become apparent.

In recent years the disease has been reported to be spreading in the districts of North Arcot, Chittoor and Bellary. The provisions of the Madras Diseases and Pests Act are being enforced in the Hospet area with a view to control the disease.

3. *Pine-apple disease* (Ceratostomella paradoxa).—This is a minor disease and has been observed in a number of districts. The fungus causes rotting of the setts before germination which results in gappiness. Very rarely standing canes are infected in advanced stages of growth.

It has been found that when the setts are treated by steeping in Bordeaux mixture before planting the disease is prevented.

The isolate of the fungus on sugarcane was compared with those occurring on coconut and arecanut. There was no difference between them and they were able to pass on from one host to another.

4. *Top rot* (Fusarium moniliforme=Gibberella fujikuroi).—This disease occurs sporadically in Tiruchirapalli, South Arcot and Coimbatore districts. It is seen only during the monsoon and the disease disappears with the clearance of the weather.

The isolate from sugarcane is allied to those from sorghum and bajra.

5. *Mosaic* (Saccharum virus 1).—It was first observed in 1925 and several of the varieties are affected. *See* also *under Virus diseases.*

COTTON (*Gossypium* spp.).

1. *Root rot* (Rhizoctonia bataticola = Macrophomina phaseoli). —This disease is prevalent in many districts. In some years, it affects young plants in the Koilpatti area, causing wilting of the plants. More often, it is found to affect older plants resulting in root rot and ultimate drying. However, the fungus is, in many cases, associated with infestation by the stem weevil. All varieties of cotton are susceptible to infection. The cultural characters of the fungus were studied. Biological antagonism exists between *Trichoderma lignorum* and this (fungus *T. lignorum* parasitises the hyphae of *R. bataticola*. The *pycnidial* stage of the fungus has been observed and identified as *Macrophomina phaseoli*. The pycnidia develop in the host plant but normal pycnidia do not develop on agar media. Other soil fungi like *Fusarium*, *Aspergillus* and *Rhizopus* do not exert any influence on the growth of *Macrophomina phaseoli*. The isolate from cotton is able to pass on to other hosts like horsegram, greengram, etc.

Experiments have shown that cotton plants raised on soil infected with this fungus twelve months previously are not infected, proving thereby that the fungus does not remain viable in the soil for such a length of time.

2. *Wilt* (Fusarium vasinfectum).—This disease is not common in the State except at Udumalpet. It affects Karunganni cotton causing typical wilt symptoms. Cultivation of resistant varieties will help to control the disease.

3. *Boll rot and seedling blight* (Colletotrichum capsici).—This fungus causes seedling blight of *Gossypium herbaceum* and *G. arboreum* but does not affect *G. hirsutum*. The disease has been observed in Coimbatore, Tirunelveli and the Ceded districts.

Later in the season the fungus infects the bolls causing spotting and finally rotting of the fruits. The acervuli of the fungus develop on the surface of the bolls. The lint is also invaded. This phase of the disease is rare.

Experiments have shown that it is seed-borne and seed treatment with Ceresan has resulted in preventing the disease.

The causal organism exhibits specialized parasitism. It has several other host plants and can be slowly made to pass on from one host to another by continuous culturing on the particular host material. It produces toxic substances in culture when the culture is three weeks old.

4. *Leaf spot* (Alternaria macrospora).—This disease is common on the leaves of young cotton plants and may lead to defoliation when the incidence is severe. Humid weather favours the disease and the disease disappears with the clearance of the weather. In restricted areas Bordeaux mixture spraying has resulted in the control of the disease.

5. *Areolate mildew* (Mycosphaerella areola—Ramularia areola).—This is a minor disease common on *G. arboreum* and *G. herbaceum* and rarely on *G. hirsutum*. It is prevalent in most of the districts. Severe infections cause defoliation. But mild outbreaks do not appreciably affect the crop. Valuable material can be protected by spraying Bordeaux mixture.

6. *Black arm* (Xanthomonas malvacearum).—This bacterial disease was first recorded from Tirunelveli in the early years of this century. In recent times the incidence of the disease has increased to a large extent especially in exotic cottons, and has been observed in many districts. On *G. arboreum* and *G. herbaceum* leaf spots alone were found in a few cultures. Observations have been carried out on the different cultures of cotton grown at the Cotton Breeding Station and over fifty cultures were selected as exhibiting fair field resistance to this disease for further investigation. These were grown in special plots and subjected to artificial field inoculation. Two cultures, viz., 79-2 and 458-1 have been found to exhibit a high degree of resistance under Coimbatore conditions, consistently over a period of four years.

This is a seed-borne disease. Seed treatment was tried as a measure of control. It was found that seed-dressing with ceresan or Agrosan GN gave control of primary infection but had no effect on the incidence of secondary infection. Rainy weather was found to be favourable for the spread of infection.

7. *Stenosis*.—This is a virus disease common in the Ceded districts and in Coimbatore on indigenous cottons. The leaves are reduced in size, branches are crowded and sterility results. Grafting experiments have shown that the disease is communicable and is caused by a virus.

GROUNDNUT (*Arachis hypogaea*) (*Nilakadalai*).

1. *Tikka disease or leaf spot* (Cercospora personata—Mycosphaerella berkeleyi).—This is common all over the State. In the early years it had caused considerable reduction in yield. The climatic conditions determine the intensity of infection.

Experiments carried out over a number of years have shown that the disease can be controlled either by spraying 3-5-50 Bordeaux mixture or by dusting sulphur. Spraying has produced an increase of 350 lb. of groundnuts per acre over the control.

2. *Root-rot* (Macrophomina phaseoli—Rhizoctonia bataticola).—This fungus causes root-rot of groundnut in the irrigated crops in South Arcot and Guntur. Infection of the roots, stem, branches

and pods takes place. The disease is partly seed-borne as sclerotia persist in the shell of the pods and on the seed coat.

Seed selection and application of lime have given satisfactory results in reducing the incidence of the disease.

3. *Clump disease* (Archis virus 1).—This is a virus disease. It is prevalent in South Arcot, Coimbatore and other districts. The plants are stunted, leaves are reduced in size and mottled and pod formation is arrested. Two species of aphids are known to act as vectors. Roguing out affected plants in early stages may prevent spread of disease.

CAJANUS CAJAN (*Redgram, Thuvarai, Kandulu*).

Wilt (Fusarium udum).—This is the most serious disease of redgram and is common in the districts of Coimbatore, Guntur and Godavari. Affected plants wilt and die.

Investigations at Coimbatore have brought out the fact that the earliest infection is seen as early as 14 days after emergence of the seedlings. The collar region just below the soil surface is infected first.

The incidence of the disease increases steadily from the fifth week and the largest number of plants die between the thirteenth and fifteenth weeks synchronizing with the reproductive period of the plant. After this there is a decline up to the twenty-fifth week when the crop is ready for harvest.

At the period of maximum infection the soil temperature is 70° to 80° F.

The fungus works its way up the stem to two-thirds the height, but the pods are free and the fungus is not seed-borne.

Application of heavy doses of green manure and cattle manure did not reduce the incidence of the disease. McRae and Shaw (1933) have reported that green manuring with sunnhemp reduces the incidence of the disease.

Seed treatment with Agrosan G. did not lead to the control of the disease.

Varietal resistance trials were conducted over a period of years. A number of varieties including some which had proved resistant elsewhere and progenies of crosses with resistant varieties like *Pusa* 80 and *Thadagam* selections, were tested for wilt resistance, in a wilt-sick plot in the Cotton-Breeding Station at Coimbatore. Twenty-seven cultures showed a commendable degree of resistance. Their disease rating varied between 3·2 and 11·6 per cent while the control showed 95 per cent infection.

DOLICHOS BIFLORUS (*Horsegram, Kollu, Ulavalu*).

Root-rot (Rhizoctonia bataticola-Macrophomina phaseoli).—This disease which results in the death of affected plants is present in many districts.

The causal organism, *Rhozoctonia bataticola* is able to infect besides horsegram, French beans (*Phaseolus vulgaris*) and blackgram (*Phaseolus mungo*). French beans are more susceptible to the isolate from horsegram, than horsegram itself. The isolate from horsegram is not able to infect gingelly (*Sesamum indicum*), Karunganni cotton (*Gossypium arboreum*) and Cowpea (*Vigna catjang*) but isolates from these are able to infect horsegram.

All parts of the horsegram plant, root, collar, cotyledonary node, shoot and leaflets are all equally vulnerable to attack by the pathogen. It is observed to be seed-borne. The plants are more susceptible in the seedling stage than when they are older, as the following record of infection indicates.

Attacks in the first fortnight	...	35 per cent.
Attacks in the second fortnight	...	10 per cent.
Attacks in the third fortnight	...	Nil.

The best method of obtaining infection was found to be to inoculate the radicles of germinating seedlings and then transfering them to the soil. By this means 50 to 66 per cent infection was obtained while by the other means only 17 to 33 per cent infection was obtained.

One of the effects of the fungus was a reduction in the length of the root system. The length of the roots of infected seedlings varied between 1·5 and 2·85 inches, while in the case of uninfected controls it was 8·7 to 13·7 inches.

The organism grows in culture at temperatures between 8° and 37° C, but the best growth was obtained at 37° C.

The soil fungus *Trichoderma lignorum* was observed to parasitise the hyphae of *Rhizoctonia bataticola*. When two-day old seedlings of horsegram were inoculated with a mixture of *Rhizoctonia bataticola* and *Trichoderma lignorum*, there was no infection while there was infection with *Rhizoctonia bataticola* alone.

The addition of a 10 per cent cultural filtrate of *Trichoderma lignorum* retarded the growth of *Rhizoctonia bataticola*.

PALMS (*Cocos nucifera*) (*Coconut, Thengai, Kobbarichettu*).

(1) *Bud rot* (Phytophthora palmivora).—This disease occurs in the districts of Malabar, Coimbatore, Madras, Chingleput, South Kanara and the Circars. Discoloured spots are seen on the leaves and leaf bases and the central expanding leaf turns pale yellow and dries up. If the disease has not affected and killed the central shoot, the tree can be saved.

The best method of control has been found to be the excision of affected leaf bases in outwardly infected trees and removal of the crown in the case of internally affected ones. The trees surrounding an affected tree should be given protective sprayings with 1 per cent Bordeaux mixture.

In the year 1949, 500 seedlings were found to have been killed in a garden. The removal of affected seedlings and protection of the healthy ones with Bordeaux mixture once in 45 days saved the rest of the garden.

(2) *Stem Bleeding* (**Ceratostomella paradoxa**).—**The disease** affects coconuts in the Circars, districts of Tanjore, South Arcot, Tirunelveli, Salem, Coimbatore, Malabar and South Kanara particularly in poorly manured gardens.

A dark-brown fluid exudes from cracks on the stem. The tissues inside rot. The disease spreads rapidly in palms of 10 to 20 years age forming big cavities. The growth is affected and yield is reduced.

The method of control developed by the department consists in the excision of diseased parts and application of hot tar to the cut surfaces, and in attending to proper cultural practices and manuring.

The same organism causes a similar disease on *Areca catechu*, the betel nut palm and similar control measures are effective.

ARECA CATECHU (*Betel nut*).

(1) '*Mahali*' or '*Koleroga*' (Phytophthora palmivora).—This is the most serious disease affecting this palm in the districts of South Kanara and Malabar, which have respectively 20,000 and 80,000 acres under this crop. The disease is also prevalent in the North Kanara district of Bombay, in Mysore and in the Travancore–Cochin Union. All these localities lie in the West Coast belt which experiences heavy rainfall during the south-west monsoon. The disease was first noticed in 1910 in Mysore and shortly thereafter in Malabar.

The affected nuts rot and fall off from the bunches. The disease spreads rapidly from tree to tree, and from garden to garden. The damage caused is heavy in some years resulting in the total loss of the crop, if timely spraying is not done. In 1936 many of the growers in South Kanara district were caught in a complacent mood. Sprayings were not carried out in time and a severe epidemic swept the plantations and growers who could not spray in time sustained heavy losses.

The casual organism was studied in detail. The optimum temperature for the growth of the fungus in culture is 30° C. The organism is heterothallic and does not form oospores when paired with other isolates from arecanut, but readily forms oospores with isolates from palmyrah, coconut, oranges, rubber and cocoa. Oospores are readily formed at 15° to 20°C, but not at 27–28° C.

The organism infects two or four-months old arecanuts readily but not so readily six months old nuts. It has a wide host range and is able to infect potato tubers, apple fruits, fruits of *Citrus nobilis* (but not of *C. sinensis*), fruits of *Artocarpus incisa, Agave wightii* and cocoa fruits,

Sporangia of the fungus have been caught in aeroscope slides at a height of 32 feet in the neighbourhood of arecanut plantations.

Spraying Bordeaux mixture for controlling the disease was advocated as early as 1913 and the method was popularized among the growers in South Malabar by systematic demonstration and propaganda for a number of years. As the control measure was found very effective, cultivators adopted it without difficulty and spraying the bunches during the season has become a recognized routine practice among areca growers in Malabar.

In earlier years it was considered necessary to add an adhesive to the Bordeaux mixture to help its retention on the bunches against the heavy monsoon rains. As a result of a series of experiments carried out in the years 1936–40, it has been established, that the use of adhesives is not really necessary and much labour and cost could be saved by using plain Bordeaux mixture. It was also found that other fungicides like cuprous oxide were not as efficient as Bordeaux mixture in controlling the disease. The optimum number of sprayings for effective control of the disease was found to be two, one just before the onset of the monsoon and another about six weeks later.

Though plain Bordeaux mixture has been experimentally proved to be as effective as, if not better, than Bordeaux mixture with adhesive, the ryots have continued to use the older formulæ including the adhesive, in spite of the inherent difficulties, in its preparation and the greater cost involved. Efforts are being made to induce the growers to adopt plain Bordeaux mixture.

The cost of control measures is about Rs. 60 per acre.

Besides the sprayings, attention should be paid to field sanitation, i.e., the removal and destruction of diseased and dried up nuts sticking to the bunches, the rotten and dried up empty hands which have already shed, the diseased nuts and the bud-rot infected crowns which form potent sources of infection. These sanitary measures are best carried out at the time of the harvest and the climbers should be instructed to remove the diseased portions as they proceed with the harvest of the nuts.

(2) *Wilt* (Ganoderma lucidum).—The disease occurs in Malabar, South Kanara and Coimbatore.

The leaves change colour from dark green to dull yellow, later they droop as if suffering from lack of water: the crown shrinks and the core of the stem becomes soft and rotten. Sometimes a coloured fluid oozes from cracks at the base of the stem. At the base of the affected palm, bracket-shaped fructifications of the fungus appear in the last stages. Te organism spreads through the soil and the disease is distributed throughout the garden.

Removal of all affected trees and application of sulphur to the soil at the rate of half a pound per tree round the base of healthy trees in the infected garden would help in checking the spread of the disease.

(3) *Stem Bleeding* (Ceratostomella paradoxa).—This disease is similar to the one found on coconut and is caused by the same organism. It is prevalent in the districts of South Kanara, Malabar and Coimbatore.

The control measure for the disease is the same as for the disease on coconuts. In addition, sun-scorching of the stem should be prevented.

PIPER NIGRUM (*pepper*).

Pepper production is seriously affected by a number of diseases, viz., *Pollu*, root-rot (*Diplodia* sp.) wilt (*Pythium* sp. and *Rzhizoctonia solani*) and stump-rot (*Rosellina bunodds*). Of these by far the most destructive is '*Pollu.*'

The Pollu disease.—The term '*Pollu*' signifies a hollow thing. As applied to pepper it means hollow and light berries. In a wider sense the term is employed to include the loss occasioned by the presence in the produce of varying quantities of improperly developed or damaged berries of poor commercial value. Losses vary and in some years are as high as 50 per cent of the marketable produce.

Investigations on the nature of the disease and the contributory factors have been carried out since 1918 and there are a number of publications on the subject. A survey of the *Pollu* and root diseases of pepper in South India was carried out in 1944.

Causes of Pollu.—Pollu is a complex problem and can be divided into three types according to the casual agent :—

(1) Spike-shedding which appears to be a physiological phenomenon,

(2) Insect *Pollu* where two insects, viz., a flea-beetle and a gall fly are involved, and

(3) Fungus *Pollu* caused by *Colletotricum necator.*

Of the three factors, spike-shedding is the most important. It is characterized by shedding of apparently healthy spikes before the period of maturity. The berries collected from shed spikes being immature become very light and partially hollow on drying, the degree of lightness depending on the stage of maturity at which shedding occurs. Microscopic and cultural studies of shed spikes of different periods and from different vines failed to show evidence of fungus, insect or bacterial attack of the stalks of the large majority of spikes. Two insects, viz., a flea beetle (*Longitarmus nigripennis*) and a gall fly also cause hollow berries. The flea beetle bites small shallow circular holes in the rind of the berry and lays eggs therein. The grubs which hatch out in five to eight days burrow into the kernels and destroy the contents and similarly hollow out neighbouring berries also. Three to four berries are destroyed by each grub. Sometimes the grub bites through the stalk of the spike when all the berries in the distal portions turn black and do not ripen.

There is a third form of *Pollu* caused by a fungus, *Collectotrichum necator.* The fungus causes shrinkage and drying up of individual berries and the stalks of the spikes are also involved. The attack begins on the leaves and stems. Circular or irregular grey spots appear on the leaves. Concentric rings of acervuli appear on the upper surface. On the stems, the attack begins at the tips and travels down to a limited extent and in course of time the stem is killed. Young vines and tender runners from old vines are killed in this manner. On old vines the attack commences at the region where the branches arise, and the fungus can be detected near the nodes of dead branches. Direct loss oif crop results from attacks on spikes and berries.

Spike shedding causes by far the greatest amount of loss. At Taliparamba this form of the disease has been noticed to cause a loss of 46·3 per cent of the berries on the variety *Balamcotta* and 37·9 per cent on *Kalluvalli* in one year. On the other hand, fungus *pollu* caused a loss of 5·6 per cent and 6·1 per cent respectively. Sometimes the loss has been noted to extend up to 13 per cent.

Control measures.—Experiments carried out at Taliparamba have shown that the application of Bordeaux mixture (½ to 2 per cent) with adhesives like resin, casein or fish oil soap was effective in controlling '*pollu*' caused by fungus attack. Besides, Bordeaux mixture acted also as repellent against flea beetle and reduced its incidence. This measure, however, was not effective in reducing spike fall (physiological). The best time for the application of Bordeaux mixture would appear to be in October so far as control of the fungus was concerned, but October sprayings sometimes had the effect of increasing mealy bug infestation of the vines during the succeeding dry weather. The mealy bugs were presumably kept in check by some parasitic fungi which were destroyed by the fungicide.

Varietal characteristics.—Two varieties, *Balamcotta* and *Kalluvalli*, were studied at the Agricultural Research Station, Taliparamba, with regard to the incidence of spike fall, *Pollu* and yield. It was found that spike fall is heavier in *Balamcotta* than in *Kalluvalli*. But the combined effects of fungus and insect *Pollu* is heavier in *Kalluvalli* than in *Balamcotta*. Besides this varietal difference, there was variation among individual vines in their susceptibility to spike fall.

Indian Council of Agricultural Research Scheme.—At the instance of the Indian Council of Agricultural Research, a survey of the pepper tracts in South India was undertaken in 1944 and based on the recommendations of the survey report a comprehensive scheme for the study of various problems relating to the pepper crop has been started and the investigation of the diseases affecting the crop forms an important item of the programme of the scheme.

CAPSICUM ANNUUM (*Chillies, Milakai, Merapakayalu*).

Fruit rot (Colletotrichum capsici).—This disease is prevalent in the districts of Coimbatore, Guntur, Tirunelveli, Madurai, Salem, Malabar and South Kanara. It is the most serious disease affecting chillies in India and losses up to 30 per cent of the crop sometimes occur. The attack occurs usually in September when the crop is in flower. Individual flowers droop and dry up. The infection reaches the stem through the flower stalk and dieback occurs. At later stage the fruits are attacked and rotted.

Two sprayings with Bordeaux mixture, one before the commencement of the attack and another at the time of fruit formation controls the disease.

The fungus is capable of infecting cotton after having been grown on cotton seed medium for a number of generations.

NICOTIANA TABACUM (*Tobacco, Pukayilai*).

Tobacco diseases.—The investigations relating to tobacco diseases were carried out under a special scheme financed by the Madras Government for five years 1912–1947. Tobacco is subject to a number of diseases. In the nursery, much damage is caused by the damping off of seedlings. In the transplanted crop. mosaic, leaf-curl and other virus diseases take a heavy toll. But by far the most troublesome enemy of the tobacco was found to be the phanerogamic parasite '*Orobanche*'.

In the earlier years, investigations on these diseases were carried out as and when opportunities occurred and certain amount of preliminary work was done. The extension of area under Virginian tobacco in the years just preceding the war in the Guntur district and parts of Godavari and Krishna and the repeated growing of tobacco year after year to the exclusion of other crops in these areas, intensified the conditions favourable for the spread of diseases with the result that in the course of a few years the diseases got the upper hand and the yield and quality of Virginian tobacco grown in the Guntur area suffered to a considerable extent.

In order to find out remedial measures for controlling the more important of the diseases which affected tobacco in these areas the scheme started work in December 1942 and the results achieved are summarized below :—

The scheme had for its programme the following items :—

I. Investigation of *Orobanche cernua.*

II. Investigation of damping off in the nurseries.

III. Investigation of other fungus and virus diseases of tobacco.

I. *Orobanche cernua* (Broom rape).—The broom rape is a phanerogamic plant which invades the root of the tobacco plant and grows parasitically on it, robbing the host plant of nourishment and water. The effect of heavy infection is loss of yield and

lowering of the quality of the tobacco leaf. The seeds of the parasite are produced in enormous numbers and are capable of remaining in the soil for a long time. A number of field and pot culture experiments were carried out with the following objects :—

(1) To find out easy and practicable methods of destroying the parasite in the field after it has appeared before it could adversely affect the crop and produce seeds for perpetuating itself.

(2) To find out methods to eradicate broom rape seed from the soil.

(3) To find out resistant types of tobacco which will not be seriously affected by broom rape infestation.

(4) To find out a suitable scheme of rotation of crop which will help to check incidence of the parasite.

The results of five years' experiments are summarized below :—

(1) The use of chemicals like copper sulphate, ferrous sulphate, Agri tree killer, Methoxone were not found superior to systematic and regular hand-picking of the broom rapes. While some of the chemicals tried were able to destroy the standing parasites they were not effective in preventing formation of new growth and hence constant application was necessary which resulted in increased costs.

The difficulty in finding out a suitable chemical is that it should be such that will destroy the parasite without adversely affecting the tobacco. The conclusion arrived at as a result of the field experiments is that hand-picking periodically was about the simplest and at the same time the most effective method of keeping down rape infestation. Surface cultivation with *Guntaka* also gave encouraging results.

(2) The following methods were tried with a view to eradicate seed from soil : (1) the use of a trap crop like *Datura fastuosa* which has a special affinity for *orobanche*, (2) the use of organic matter of sunflower, etc., to induce germination of seed in the absence of host plant. The results of experiments carried out during the five years showed that *orobanche* could not be controlled either by incorporating organic material in the soil or by growing *Datura fastuosa* as a trap crop under Guntur conditions. However, the finding that *Datura fastuosa* has a great affinity for *orobanche* was an important one, as the possibility of its being utilized for eradicating *orobanche* under other conditions is not ruled out. In the course of pot culture experiments carried out, it was found that chillies stimulated germination of *orobanche* seed in the soil without themselves being parasitized. This finding is also of great significance inasmuch as it indicates that the growing of chillies (though a solanaceous crop) in rotation with tobacco will not result in the multiplication of the parasite

(3) With regard to varietal resistance, though some varieties like ' Dumbari ' and " Country rat tail " showed higher resistance than others in some trials, the results were not conclusive as their superiority was not consistently significant in all the trials carried out during the five years.

(4) Contrary to the experience recorded by previous workers elsewhere, it was found that the seed of *Orobanche cernua* rarely remained viable for more than two and a half years and therefore a three-year rotation of crop in the Guntur area (tobacco coming once in three years or more) may help in reducing rape incidence. The scheme was closed before conclusive results could be drawn on this aspect from the experiments laid out.

Host range of Orobanche.—Astudy of the host range showed that it could parasitise *Datura fastuosa* (purple), *D. fastuosa* var. *alba*, *D. stramonium*, *Lycopersicum esculentum*, *Nicandra physaloides*, *Nicotiana affinis*, *N. glauca*, *N. glutinosa*, *N. rustica*, *N. sandaræ*, *N. tabacum*, *Petunia* sp., *Physalis minima*, *Solanum melongena*, *S. nigrum*, *S. tuberosum*, *S. xanthacarpum*, *Withania somnifera*, *Helianthus* spp., *Carthamus tinctorius*, *Acalypha indica*, *Euphorbia prostrata*, *Corchorus capsularis*, *C. trilocularis* and *Cannabis sativa*.

The results of five years experiments showed that systematic hand-picking of broom rapes as they appear and the practice of rotation (tobacco crop being grown once in three or four years) would help in reducing broom rape incidence.

II. *Investigations relating to control of Damping off*.—Damping off of seedlings caused by soil fungi, chiefly *Pythium aphanidermatum* results in heavy loss to the farmer in the Guntur area and a number of field experiments were laid out to find out the best method of control of this disease.

It was found that spraying the nurseries with one per cent Bordeaux mixture at the rate of 500 gallons per acre once every fortnight commencing from 20 days after sowing was effective in completely controlling the disease. The cost of treatment was found to commensurate with the profits gained as severe incidence of disease completely wiped out the seedlings from seed-beds which have been raised with considerable amount of labour and trouble.

The practice of spraying the nurseries has been popularized among the farmers and has been taken up by them with enthusiasm.

III. Investigation of other fungus and virus diseases of Tobacco. *Black shank* (Phytophthora palmivora).—The disease was noticed for the first time in South India in 1930. It is characterized by the blackening of the stalk and subsequent rapid wilting of the tops. Infrequently it occurs in the nurseries as a " damp off " of seedlings with blackening and rotting of the basal portions of the stem. In the field the black rot of the stem commences near the soil line and extends up the stem and down the roots.

The disease occurs in the districts of Salem, South Arcot and Coimbatore.

Of the control methods tried, burning trash on nursery beds and periodical spraying of the transplanted crop were effective in controlling the disease. The Bordeaux mixture was most effectively

applied down the stem so as to drench the soil around it. Over-irrigation should be avoided.

The organism was found to be capable of utilizing urea as a source of nitrogen in culture. The fungus *Trichoderma lignorum* disintegrates it in culture.

CITRUS MADERASPATANA.

Water injury.—This disease is found affecting the Vadlapudi oranges (*Citrus maderaspatana* Tanaka), a bitter sweet variety in the Vijayavada area of Krishna district and parts of Guntur district. Trees in apparently good health and bearing heavily are found to wilt away suddenly within the space of a week. The leaves and immature fruits drop away. There is a complete ring of injured bark at the foot of the tree. Trees with one or two patches of healthy bark breaking the continuity of the ring remain apparently healthy in spite of extensive injury on other sides. The root system is completely or partially attacked and the wood is stained black. Feeding roots are sparse and look unhealthy. The cortex of such roots easily sloughs off.

Isolations from the injured portions yielded *Diplodia* sp., *Sporocybe hybrida* and *Haplosporella* sp. But these are believed to be either secondary invaders or at best weak parasites.

There was a popular belief that the disease was due to the proximity of tanneries to citrus gardens. But observations have revealed the existence of the disease even in gardens miles away from any tannery. Hence this possibility was ruled out.

The water table at the beginning of the rainy season was found to average about 6·8 feet in the affected areas. The trees are flood irrigated at intervals of 10 days and the irrigation water comes in direct contact with the stem. Flooding also stifles æration in a clayey soil.

After a number of trials, the following measures were found to be successful :—

(1) Changing from flood irrigation to ring irrigation.

(2) Scraping away the diseased bark, excision of affected roots, and protection of wounds with Bordeaux paste followed by a coat of shelmac.

(3) Digging of drainage channel across the gardens and connecting them to natural drains or deep pits in a corner of the garden.

(4) Removal of sticky soil from the base of the trees and replacing it with a mixture of sand, coppersulphate and lime.

These treatments are successful only with trees showing early symptoms of disease. They do not afford permanent protection in an area where the water table is high during the monsoon period.

CITRUS RETICULATA (MANDARIN ORANGE).

Leaf fall and fruit rot (Phytophthora palmivora).—This disease causes heavy damage in the orchards of Malabar (Wynaad). It is a disease occurring during the heavy rainfall of the south-west monsoon. It first attacks the leaves and then spreads to the twigs and fruit causing heavy defoliation and the rotting and shedding of the fruit. The crop may be totally lost as even the few apparently healthy fruits that may be collected become diseased and rot during storage and transit.

The results of the experiments carried out for three consecutive years in a heavily infested area in Wynaad showed that the disease could be effectively controlled by the application of one per cent Bordeaux mixture. Two sprayingcs, the first just before the onset of the monsoon in June and the second after the onset of the monsoon in August or September, were fund to give the best results in controlling both leaf fall and fruit rot. Of the two sprayings the latter spraying is the more important and essential in controlling infection of the fruit.

As the available time for carrying out spraying operations during the monsoon period is short, it is necessary to have the spraying operations done with the aid of efficient sprayers and preferably with power-driven spraying equipment in large orchards. The control measure was popularized among the growers and has now become a routine orchard practice in the area. The cost of treatment is about Rs. 30 an acre.

BANANA (MUSA PARADISIACA).

' *Wilt* ' *or* ' *Panama disease* ' (Fusarium oxysporum var. cubense).—This disease occurs in the districts of Visakhapatnam, Godavari, Madurai, Coimbatore, Salem and Malabar. It is characterized by the yellowing, wilting and buckling of the outer leaves which hang pendant from the broken petiole. The topmost leaf withers last and the pseudostem dies. The leaf sheaths on the pseudo stem are longitudinally split. Stunting is also observed and new suckers arising from affected rhizomes are also affected.

It was found that only a few varieties of banana were susceptible to the disease, like ' Rasthali ', ' Poovan ' and ' Mondan '.

The method of controlling the disease is to select disease-free suckers for planting and eradication of affected plants. Destruction of affected rhizomes in which the fungus thrives and sporulates is important. The use of certain chemicals like ' Malariol ' and " B liquid fuel " for destroying rhizomes *in situ* and preventing the sporulation of the pathogen was successfully tried but the cost of treatment came to Re. 0–5–6 and Re. 0–2–6 per plant respectively and it was found that it was cheaper to cut down and bury the clumps *in situ*.

Fortunately, banana is invariably a rotational crop, occupying the land only for three years. The maiden crop is usually free. In the first ratoon, disease incidence is almost negligible. It is only in the second ratoon, which is usually only a ' leaf ' crop, that the attack increases. After the second ratoon, the land is usually cropped to sugarcane and rice and the pathogen no longer finds a congenial host.

VITIS VINIFERA (*Grape Vine*). (*Dhrakshai, Dhraksha*).

Two important diseases seriously affecting the vine are, (1) Downy mildew (*Plasmopara viticola*) prevalent in the districts of Madurai, Coimbatore and Salem, and (2) Powdery mildew (*Uncinula necator*) prevalent in the districts of Anantapur, Salem, Coimbatore and Madurai.

The downy mildew manifests itself by the formation of irregular " oil spots ", yellow at first but later turning brown on the upper surface of the leaves. The lower surface of these spots is covered by a white downy growth. In advanced stages the leaves wither and die. When the berries are infected at an early stage they remain small and become shrivelled and dry. Continued moist and warm conditions favour the spread of the disease. The powdery mildew attacks all green parts. It appears as white patches on both the surfaces of the leaves, later covering the entire leaf and spreading to the shoots, flowers and berries. Berries shrivel and drop off.

Experiments have been conducted at Michælpatti in Madurai district which showed that the disease can be kept in check by periodical sprayings of 1 per cent Bordeaux mixture. The number of sprayings depends on the local weather conditions. The cost of spraying comes to Rs. 80 per acre and spraying has become a regular routine operation with the growers. The grower gains at least Rs. 1,000 per acre by resorting to regular spraying.

A third disease which has been recorded from Madurai, Coimbatore and Salem districts is *anthracnose* or " bird's eye " disease caused by *Elsinœ ampelina*. The disease is characterized by brown, black-bordered sunken spots on the stem, leaves and berries.

The vines should be thoroughly sprayed with one per cent Bordeaux mixture soon after pruning. Further periodical applications of spray to the foliage and berries will be necessary. The measures adopted for the control of downy mildew will be able to keep this disease in check.

CASUARINA EQUISETIFOLIA (*Chavuku. Sarvi*.

Wilt—Trichosporium vesiculosum.—The wilt was first recorded in 1905 from Ganjam. Later it has been noticed to cause appreciable damage in the districts of Nellore, South Arcot, Tanjore and Tirunelveli. The trees wither and die and in the course of a few months, the bark ruptures exposing masses of powdery, black spores.

There used to be a belief that the death of the trees was due to either excess of water or lack of it, and not due to any pathogen.

Experiments were carried out at Coimbatore on the cause of the disease. The fungus, *Trichosporium vesiculosum* was isolated from the spores obtained from dead trees in the Nellore area. The organism grows luxuriantly and sporulates freely on potato-dextrose and oat-meal agars.

Trees four to six years of age were inoculated with the pure culture of the organism. The inoculum was placed under the bark and bound up with wax cloth. Suitable controls were maintained.

Two months later, the seat of inoculation was observed to have turned brown and spores were produced in a few fissures in the bark. The trees began to wither after six months. In the course of another two months, the trees were dead, with typical symptoms. The bark was ruptured and quantities of the spore powder were observed under the bark. The formation of spores was evident in some at the base and in others in the upper portions of the stem. All the six inoculated trees died while all the controls were healthy. It is evident that the wilt of *Casuarina* is caused by *Trichosporium vesiculosum* which is a wound parasite. Since, in nature, rupturing of the bark of *Casuarina* is common, entry of the pathogen is facilitated.

Previously, isolation of diseased patches by trenching used to be recommended. However, in the light of the findings shown above, and the profuse production of airborne spores by the pathogen, this recommendation may not be effective in preventing the spread of the disease.

RUBBER (*Hevea brasiliensis*).

Abnormal leaf fall (Phytophthora palmivora).—In South India rubber is chiefly grown in the south-western region of the peninsula along the outer fringe of the western ghats in Malabar, Cochin and Travancore. Isolated plantations are situated on the Anamalais, Nilgiris and Shevroys. As early as 1910 attention was drawn to the prevalence of a disease in some of the plantations resulting in the rotting of fruits and shedding of leaves during the monsoon. Larger areas were affected later and heavier incidence of the disease has been recorded since then. The disease was completely investigated by the Mycology section between 1917 and 1922 and several experiments were carried out at Mooply valley and Mundakkayam.

On the West Coast rubber trees normally shed their leaves during December and January. But a second and abnormal leaf fall occurs on infected estates during the monsoon in June to August. Some of the trees lose all their leaves and stand bare. The invasion of a fungus *Phytophthora palmivora* (*P. meadii*) has been found to be responsible for this. Besides causing leaf fall the fungus causes fruit rot, rotting of the bark near the tapping cut and a partial die

back of branches. The yield of latex is reduced. The fungus remains in the diseased fruits sticking to the branches and in the tissues of branches affected by die-back.

The first trials at controlling the disease were directed towards the removal of the parts of the plant where the fungus remained dormant during the dry seasons. Special gangs of labourers were entrusted with the task of removing the old fruits and pruning the branches showing die-back. There was distinct improvement in the control of the disease as a result of these measures. Later it was thought advisable to protect the leaves from fresh infection in addition to the sanitary measures. With this object Bordeaux mixture was sprayed on the leaves before the commencement of the disease. The effect was very encouraging and the incidence of the disease was greatly reduced and the yield of latex increased. The remedial measures were so convincing that at the present day it is being universally adopted in all well-maintained estates. Battery sprayers and power-operated sprayers are being used for this purpose.

Powdery mildew (Oidium heveae).—In recent years this disease has been observed in many of the estates. Powdery white growths develop on the leaflets. Defoliation is evident in some estates. The disease is caused by an obligate parasite—*Oidium heveae*. The disease is present on young and old plants.

Like all powdery mildews this disease is amenable to sulphur dusting. Power dusters will be more useful and effective in carrying out this treatment as the trees are tall.

Root disease.—These are caused by various fungi, viz., *Botryodiplodia theobromæ, Fomes noxius, Ustulina zonata Rosellinia* sp., etc. Some of these are traceable to infection from rotting stumps of jungle trees. Location of the focus of infection and its eradication led to the diminution of the disease. The provision of cover crops also resulted in the reduction of these diseases.

COFFEE (*Coffea arabica and other species*).

Rust or leaf disease (Hemileia vastatrix).—This is by far the most important disease of coffee in South India and is prevalent in all the planting districts. It is most severe on *C. arabica*. The disease manifests itself in the form of brown spots, on the upper surface of the leaves. On the corresponding lower surface a yellow or orange powdery formation is present. This is made up of the spores of the rust. All but the youngest of the leaves are affected and very often many of them are shed.

The disease increases with the onset of the south-west monsoon in June and continues till November after which the incidence is low. The annual recurrence of the disease devitalises the bushes and the bearing is very much reduced. The bushes eventually fall a prey to other diseases.

Experiments were carried out at the Coffee Experiment Station, Sidapur, Coorg, over a number of years on the control of this disease. It was found that two sprays of half per cent Bordeaux mixture once in May before the monsoon and again in September gave good control of the disease. It was necessary that the lower surface of the leaves should be thoroughly protected. The spray operations resulted in increased yields of coffee. Thus the bushes were saved from the devastating effects of the disease and a greater outturn of coffee was secured.

Another line of investigation was directed towards the selection of resistant varieties of coffee and the determination of the factors influencing resistance. The rust was found to be very rare on *Coffea robusta*. Other cultures like "*Kents' arabica*" and "*Johnson's hybrid*" were also examined. The behaviour of these cultures was not found to be consistent. The number and distribution of stomata in the leaves of the susceptible and resistant varieties were determined to find out if there was any correlation between resistance and these factors. There were indications that the size and number of the stomata were important factors.

Koleroga—Black rot (Pellicularia koleroga).—This disease was prevalent in some of the estates in Coorg and Mysore and rarely in other areas. A thin layer of fungal hyphæ grew over the leaves and twigs. The affected portions soon turned dark brown or black. The leaves broke off from the twigs and could be seen suspended from them by the fungal strands.

The disease was more intense under dense shade and in low lying portions of the estates exposed to high rainfall. The incidence of the disease synchronised with the commencement of the monsoon.

Experiments on the control of this disease were carried out over a number of seasons and it was found that spraying the plants with Bordeaux mixture and reducing the shade reduced the incidence of the disease.

Brown blight (Glomerella cingulata) (Colletotrichum coffearum).—This is common in South India forming roundish brown spots on the leaves. Twigs and berries are also affected. Die-back of branches may be caused. The disease was found to be amenable to Bordeaux mixture spray treatment. But repeated sprays were necessary. There were indications that the disease was more in areas which were not receiving adequate manuring or on bushes growing in poor soil.

Since the institution of a Scientific department by the United Planters' Association of Southern India the investigation of coffee diseases by the Mycology section was discontinued.

TEA (*Camellia thea*).

Blister blight (Exobasidium vexans).—This crop was fairly free from serious diseases till the year 1946 when widespread outbreak

of *Blister blight* caused by *Exobasidium vexans* was recorded from almost all the tea estates in South India.

The disease occurred in waves reaching peak incidence in July to August and October. It subsided during the dry season. Young leaves and shoots were vulnerable while mature leaves escaped. An appreciable loss in yield was experienced.

The Madras Pests and Diseases Act was applied for one year in 1947 but as the disease had spread to all estates the enforcement was discontinued. Spraying the plants with Burgundy mixture gave protection in the nursery but in the absence of suitable equipment large scale spraying could not be carried out. Further it was not known whether the deposit of a copper fungicide on tea leaves used for tea manufacture will affect the quality of tea or infringe the food regulations. As a palliative the pruning dates were changed in order to avoid the development of tender leaves and shoots in June. Shade was reduced to let in more sun and lessen the humidity round the bushes. Search for resistant clones may yield a better solution.

The forest trees in the vicinity of tea estates were examined to find out if any alternative hosts were present. *Exobasidium* was found on *Gordonia* belonging to the same family as tea but the fungus on the former host did not pass on to tea even when artificially inoculated. No other alternative host has till now been recorded in South India.

DISEASES CAUSED BY VIRUSES.

In recent years considerable attention is being devoted to the study of a group of plant diseases caused by viruses. These diseases are infectious and are transmitted from plant to plant by various agencies; insects playing a predominant part. The nature of the disease producing entity known as 'virus' still remains unknown. Viruses are unlike bacteria or fungi, invisible to the human eye even with the aid of the most powerful microscope, though in recent years the electron microscope enables a few viruses to be photographed. The infective principle can pass through filters through which the minutest known living organism cannot pass through and still retain its infectivity. Viruses cannot be cultivated outside the living cell. In some respects they behave like living oganisms in that they can multiply of their own accord in living tissues. Many of them are also specific in their parasitism. In other respects they behave like inanimate substances and a few viruses can be extracted and preserved in a crystalline form without losing their infectivity. The viruses are now regarded by a school of scientists as a separate group occupying a place between living organisms and inanimate matter.

As the virus is not a visible organism its presence can be judged only by the symptoms it causes to appear on the host plant. But

as similar symptoms can be caused by different agencies, the presence of virus can be confirmed only by carrying out transmissibility trials (i.e), the disease must be capable of passing on from diseased to healthy plant, care being taken to eliminate other organisms like bacteria and fungi.

The study of the virus disease of plants in the State of Madras began in 1923 with the investigation of the mosaic disease of sugarcane. Since then a number of diseases of different crops has been studied. However, owing to the special facilities which the detailed investigation of diseases caused by virus demands, the progress of work in this direction has been impeded, and as these diseases are of great economic importance, the systematic pursuit of the studies relating to them should be undertaken in the future and for this, provision of adequate facilities and specially trained staff are necessary.

(1) *Sugarcane mosaic.*—The occurrence of this disease was first noticed in 1923 in the variety Red Mauritius in the cane fields belonging to the East India Distilleries and Sugar Factories, Nellikuppam, in the district of South Arcot. This variety which had done well previously was found to be rapidly deteriorating on account of the disease. As reports of the disastrous effects of the disease on cane production were received from Puerto Rico, Lousiana, Cuba and other cane-producing countries of the world, a study of the disease with special reference to the methods of its control was started. A preliminary survey of the cane area of the State revealed that the disease was present more or less throughout the State. But the incidence was not of such a magnitude as to affect the yield except in certain specific varieties and there was a wide range of variation in the varietal susceptibility to the disease. As a first step towards control of the disease in the Nellikuppam area, the variety Red Mauritius was eliminated from cultivation and other tolerant and less susceptible varieties were substituted. Roguing out of infected clumps and planting with disease-free material after careful selection brought the disease under control in the area. In connection with the investigation of sugarcane mosaic the following aspects were studied :—

(i) *Varietal resistance.*—Field experiments were laid out to evaluate the relative resistance of varieties of cane and were continued up to the year 1948. During this period about 150 varieties which included all the varieties grown in this State, together with the new varieties released from time to time by the Imperial Sugarcane Expert were tested. A wide range of varietal susceptibility was noticed. A few varieties like Kassoer, *CO* 214, *CO* 244, *POJ* 2878, *POJ* 100, *Uba SH* 38 and *Uba SH* 281 were found to be consistently highly resistant. *CO* 213, *Red Mauritius* and other *Mauritius* canes *Vellai*, *Poovan*, the *Barbados* varieties *B* 2412, *B* 208, *Pattapati Java Hebbal* and *CO* 419 were found to be highly susceptible. The degree of susceptibility of other varieties like *Fiji B*, *Fiji C*, *CO* 421, *POJ* 2714, etc., was found to be intermediate between these two extremes.

(ii) *Loss due to the disease.*—Field experiments carried out for a period of three years with the variety CO 213 showed that (1) there is an appreciable loss in tonnage, (2) that the sugar content and purity of the juice are affected and (3) that the adverse effect of the disease is cumulative, i.e., by planting diseased setts year after year, the loss is increased. The experiments relating to this aspect were carried out at the Agricultural Research Station, Taliparamba, as chances of secondary infection vitiating the experiment were found to be negligible in that locality.

(iii) Experiments carried out at Coimbatore showed that the disease is not transmitted through the true seed.

(iv) *Other hosts of the Virus.*—Sorghum, Maize (*Zea mays*) and the grass *Echinochloa colona* were found to be hosts of sugarcane mosaic in South India.

(v) *Methods of control in the field.*—Systematic roguing out of diseased plants and planting healthy material were found to be effective in the Sugarcane Breeding Station and the Central farm wet land at Coimbatore.

(2) *Tobacco virus diseases.*—The following virus diseases of tobacco have been recorded in South India (1) Mosaic, (2) Leaf curl and (3) Ring spot. Among these the Mosaic disease is by far the most important. Investigation showed that different viruses are causing mosaic symptoms, including the destructive Nicotiana virus and the comparatively innocuous cucumber mosaic virus (*Cucumis virus* 1) which does not affect the yield or quality of the leaf of tobacco to any appreciable extent.

Control measures for the mosaic disease would appear to be the eradication of diseased plants and paying careful attention at the time of suckering and topping to avoid contamination of healthy plants and the use of clean seed free from debris.

At Guntur, studies on varietal resistance in respect of mosaic showed that among the 49 varieties tried all were susceptible

The other two virus diseases of tobacco, viz., Leaf curl (*Nicotiana virus* 10) and Ring spot (*Nicotiana virus* 12) are reported to be of great economic importance elsewhere, but in South India their incidence is negligible.

(3) *Potato diseases.*—A number of virus diseases of potato have been noticed to occur on the Nilgiris, and there is reason to believe that the steady deterioration in production in the hills may be partly due to the prevalence of virus diseases. The diseases recorded are Mosaic, Leaf roll (*Solanum virus* 14), Aucuba mosaic (*Solanum virus* 9), crinkle (*Solanum viruses* 1 *and* 3). As there are a number of strains of potato mosaic, each different from the other in its effect on the crop, a detailed investigation of this aspect is necessary and has to be undertaken in the future. It would also appear to be necessary to institute a system of seed certification for ensuring that healthy seed is planted. For want of facilities and lack of staff the work has not yet been undertaken on a systematic and organized scale.

(4) *Brinjal—Little leaf—Datura virus* 2.—A widespread virus disease of *brinjal* was investigated in detail. The disease was found to be transmissible by grafting and with the aid of an insect vector a jassid *Eutettix phycitis.* The disease was found to be transmissible to a wide range of solanaceous hosts and among these *Datura fastuosa* would appear to be responsible for harbouring the virus in the cultivated fields during the off season.

Roguing out diseased plants and keeping the fields free from solanaceous weeds were effective in checking the disease.

(5) *Cotton stenosis.*—A disease of the cotton plant characterized by reduction in the size of leaves, stunting of the plant, phyllody, and sterility was found to be responsible for considerable amount of damage in the " *Mungari* " cotton grown in the Ceded districts tract of the State. On investigation, the disease was found to be due to a virus and it was established that the disease was not transmissible by sap inoculation but only through grafting.

Varietal resistance experiments showed that all indigenous varieties are susceptible to a greater or lesser degree but exotic types like Cambodia are immune. The incidence of the disease is greater during " *Mungari* " season than in the " *Hingari* " season on the same types.

The preliminary investigation of the disease was carried out by the Mycology section of the Agricultural College and Research Institute, Coimbatore, in the years 1940–1942, but at the instance of the Indian Central Cotton Committee, further investigation of the disease was carried out under a special scheme at Poona. A jassid has been found to be the vector of the disease. Roguing out diseased plants in the very early stages of the crop is helpful in checking the disease.

(6) *Bendai* (Hibiscus esculentus (Mosaic).—The disease has been recorded from all over the State. It is transmitted by the white fly "Bemisia tabaci ". The investigation of the disease is being carried out at Poona under a special scheme. Control measures would appear to consist in roguing out diseased plants and the use of insecticides and insect repellents to minimise chances of the spread of infection.

(7) *Papaya* (Carica papaya) (Leaf curl).—A virus disease of the papaya plant has been investigated and was found to be transmissible by grafting. The disease, however, is of no economic importance in South India.

(8) *Tomato diseases.*—Mosaic, leaf-curl and crinkle diseases of the tomato have been observed to occur in the State.

(9) *Cardamom mosaic.*—The mosaic disease of cardamom appears to have been prevalent for over four decades but it was only in 1933 that the disease was definitely known to be of virus origin. This disease has been responsible for the progressive deterioration of the cardamom plantations in the Anamalais and Palni

hills and by the year 1939 most of the plantations had to be abandoned as unremunerative. The disease is characterized by mottling of leaves and reduction in the size of plants. The yield is adversely affected. Investigation of the disease showed that the disease was not sap transmissible. Transmission experiments carried out at Valparai with thrips (*Taeniothrips cardamomi*) gave negative results. Subsequent transmission experiments carried out at Poona showed that the vector is an aphid " *Pentalonia nigronervosa* ".

The disease is perpetuated by planting rhizomes from diseased plants and as a measure of control, planting of rhizomes from healthy plants was recommended. The disease is not carried through true seed and raising nurseries from true seed would also appear to be helpful in keeping the disease away from new plantations. Under the special scheme for scientific aid to the cardomom industry in South India, varietal resistance experiments are in progress. Evolution of disease resistant types is being attempted by selection and hybridization.

DEFICIENCY DISEASES.

The soil is being continuously depleted of its mineral plant nutrients by plants. Though part of these may be returned to it by the decay of plant parts left behind, a major part is lost. Manuring is resorted to in order to replenish the loss. It is now known that besides the major elements essential for plant growth and which form the bulk of the body of the plant, certain other elements are also required in extremely small quantities. For this reason they are known as minor elements or ' trace elements ', or ' micro-nutrients '. The absence of these elements leads to the development of pathological symptoms and has been the subject of considerable study.

(1) *Boron deficiency of certain vegetables.*—During the war, vegetables were grown on a large scale on the Nilgiris for being supplied to the army. Turnips (*Brassica campestris*), Beet root (*Beta vulgaris*) and Cauliflower (*Brassica oleracea var, botrytis*), which were important vegetables grown over extensive areas were found to develop certain pathological symptoms.

The core of the tuber of turnips was soft and presented a discoloured water soaked appearance instead of being white and hard as in normal turnips. In the case of the beet, the heart was often found rotten and blackened and the young leaves at the top were also affected. Cauliflowers in certain places failed to develop the normal creamy 'curd ', but had flowers of varying shades of brown. Pathogenic organisms were not observed to be associated with these conditions. All the symptoms pointed to the possibility of their being caused by a deficiency of boron in the soil. Field experiments were conducted for over two seasons on the control of the water core of turnips. Boron was applied to the soil in the form of boric acid prior to sowing at the rate of 5, 10, 15 and

20 lb. per acre. Spray inoculation of a 0·2 per cent aqueous solution of boric acid on the foliage of the seedlings was also included as one of the treatments. An examination of the tubers from the various plots showed that all the treated plots had little or no symptoms of disease and that spray application was as effective as application to the soil. Based on these experiments the application of boric acid to the soil at the rate of 5 lb. per acre, where the deficiency has been noticed, is being recommended on the Nilgiris.

Boron deficiency also affects the growth of many other crops. It should be remembered, however, that excess of boron is toxic to plants and this must be borne in mind in recommending the dosage of the element for application.

(2) *Foliocellosis or Mottle leaf of citrus*.—Zinc is another micro-nutrient, the deficiency of which is evident in many orange orchards of *Citrus sinensis* all over the State. The growth of the tree is arrested. The leaves develop characteristic yellow blotches between the veins. There is a progressive reduction in leaf size, few fruits are produced, and in course of time the tree deteriorates and falls a prey to various pathogens.

The initial experiments were carried out at Panyam (Kurnool district) and Kodur (Cuddapah district).

Six spray treatments and two soil treatments were tried in these places. The following chemicals were used in the spray treatments, viz., zinc sulphate, magnesium sulphate, ferrous sulphate, manganese sulphate, copper sulphate and a combination of all these chemicals. The chemicals were dissolved in water to obtain a one per cent solution, neutralized with lime and sprayed on the foliage. In the case of the soil treatments, zinc sulphate and magnesium sulphate were applied. They were applied to holes nine inches deep all round the tree and covered, or broadcast on the soil round the tree and forked in.

It was observed that there was no response to the soil treatments. Among the spray treatments zinc sulphate and combination spray resulted in the recovery of the trees, indicating thereby that zinc is the element in deficit. It was also observed that the recovery was not permanent. It was found that zinc sulphate-lime mixture of the formula of 5—2½—100 was best for trees showing the initial stages of the deficiency symptoms and a mixture of the formula of 10—5—100 yielded good results in the case of trees having severe and chronic symptoms.

It was found that it is best to spray when the trees are in flush. It is better not to spray when the trees are in flower. But experience in the State has shown that there is no harm if trees with fruits are sprayed provided the mixture is properly neutralized. Two spray applications are necessary and can be carried out during the period of flush in each locality. In addition to the spray, applications of large quantities of farmyard manure is also beneficial.

Wide publicity has been given to these results and five tons of zinc sulphate were distributed to orange growers in 1947 and larger quantities are being used at present.

(3) *Deficiency of copper in citrus.*—Citrus sinensis in the Circars commonly suffers from "*Exanthema*" a kind of "die back" due to the deficiency of copper in the soil. In the initial stages the young branches are frequently angular and 'S' shaped with multiple buds instead of being cylindrical and having one bud as in normal plants. In acute cases the branches die back and gum pockets develop at the leaf bases. The branches may be covered with gummy excrescences. Defoliation takes place. The rind of the fruit may also exhibit hard brown excrescences.

It was found that spraying the trees with Bordeaux mixture resulted in marked response and the symptoms disappeared. Thus Bordeaux mixture which is usually sprayed as a fungicide can also make good a deficiency of copper. Copper applied to the soil resulted in good response. It was applied in the form of copper sulphate at half to two pounds per tree either alone or mixed with other fertilizers.

It is a common experience in many orange gardens that by spraying Bordeaux mixture, the production has increased even in the absence of fungal diseases.

(4) *Decline of the Mandarin Orange—Citrus reticulata.*—A decline of orange trees has been noticed for some years in the submontane tracts of the Shevaroys (Salem district), Kotagiri (The Nilgiris), Wynaad and Coorg. At Kukal (Nilgiris) and the Shevaroys the symptoms consist of mottling and chlorosis followed by gradual defoliation. Experiments were conducted at Yercaud in the Shevaroys to see the effect of spraying the foliage with zinc sulphate, iron sulphate and manganese sulphate individually and in combination. There was little response. Soil applications also did not result in improvement.

The soil from the base of affected trees in the Kotagiri area was analysed and found to be deficient in phosphorous. However, adequate response was not obtained from the application of phosphatic manures alone.

It is known that the analysis of the soil for diagnosis of the deficiencies of trace elements has not yet been developed sufficiently, and cannot be wholly relied upon. Visual symptoms of mineral deficiencies exhibited by plants especially the orange, sometimes overlap and it is often difficult to say what particular element is wanting. There are two ways of tackling the problem. One is to grow indicator plants and the second is plant analysis. The latter is a quicker and reliable method and gives a correct picture of the nutritional status of the plants. The analysis of the plant material can be carried out either by the usual laboratory method or by the spectrographic method.

With the co-operation of Dr. Patwardhan, Director of the Nutrition Research Laboratory, Coonoor, and Dr. De, Assistant Chemist, representative leaf samples from an estate in the Kotagiri area were spectrographically analysed. Comparative readings for healthy trees were also taken. Several such analyses revealed that the leaves of diseased trees were deficient in several elements. Zinc was absent in all cases. Deficiencies also of phosphorus, manganese, magnesium and boron were found. There was no difference between healthy and diseased leaves in respect of calcium and iron.

There is agreement between soil and leaf analysis with regard to the deficiency of phosphorus. But the deficiencies of trace elements like manganese, magnesium, boron and zinc could not be made out in soil analysis. There is, however, the possibility that these minerals, though present in the soil, are not in a form available to the plant. Citrus trees grow well at a soil reaction of pH 7, but often nutrient substances in the soil do not become available at this reaction. The soil at Kodaneri Estate (Kotagiri area) was found to have a reaction of pH 7. Moreover, lack of boron is known to inhibit the absorption of phosphorus from the soil.

Work is in progress to try the effect of spraying combination mixtures of the elements in deficit on the foliage.

Diseases due to physiological causes.

These are diseases for which no pathogen is responsible and which are not due to malnutrition. They are due to the upsetting of the normal metabolism of the plant on account of unfavourable physical factors of the environment. An account is given below of the investigations made into the " Black-heart " of potato, a physiological disease.

The Black-heart of potato.—This is a condition seen in stored tubers. Affected tubers when cut open are seen to have a brown or black colour in the interior. The discolouration commences at the centre and progresses towards the periphery either as a star-like radiation or as a mere uniform advance. The disease is caused by an insufficient supply of oxygen to the tuber, combined with high temperatures.

There are few records of the occurrence of " black heart " on the Nilgiris. A consignment sent from Mettupalayam to Secunderabad by rail was reported to have developed the disease at its destination. In November 1941, Messrs. Parry & Co., Ltd., sent samples of processed potatoes showing a black discolouration. On examination, they proved to have been affected with black-heart.

Black-heart was produced experimentally on healthy potatoes kept in an incubator at 38°C. A consignment from Ranipet developed black-heart in one day while Ootacamund samples took two days. It was observed that typical black-heart symptoms gradually developed in the course of five days.

Experiments simulating factory practice were conducted to see whether the development of black colour could be prevented in the early stages of black-heart by throwing the cut slices directly into water and balancing them immediately on removal from water. It was found that the colour developed in the drying process.

The investigation showed that "black-heart" developed in potatoes stored in ill-ventilated godowns and exposed to high temperature during transit and the disease could be avoided if the godowns and transport wagons were properly ventilated.

Chemicals used in plant protection.—Various chemicals are used in protecting crops against diseases. They are applied either in the form of a spray, steep or in the form of a dust so that the vulnerable surfaces of the host are covered or the spores on the surface are killed. A good fungicide should be toxic to the parasite or inhibit the germination of its spores, without being injurious to the crop plant It should be reasonably easy to prepare, safe to handle and cheap enough to be of use. It should be capable of even distribution when applied through sprayers or dusters on the surfaces to be covered. It should not run off too freely. It should adhere well to the surface. An account of the more common fungicides in use in the State is given below.

Some useful recipes—Bordeaux mixture.—Since its discovery and use by Millardet in 1882–1896, Bordeaux mixture has been the leading fungicide for control of diseases affecting grapes, fruit trees, potatoes and many other crops. The various strengths used are expressed by formula. For example 5—5—50 consists of 5 lb. of copper sulphate plus 5 lb. of quick lime (unslaked) in 50 gallons of water. An important function of the lime is to hold the copper in a form not harmful to the crop but toxic to parasitic fungi.

Bordeaux mixture—one per cent—

Copper sulphate	One pound.
Quick lime	One pound.
Water	Ten gallons (100 lb.)

Preparation.—Dissolve the copper sulphate in five gallons of water in a wooden, earthenware or copper vessel. It is better that the copper sulphate is tied up in a piece of gunny and suspended just below the surface of water as it gets dissolved quicker that way. Slake the quick lime in another vessel by sprinkling some water over it and add more water till a creamy paste is formed. Add the remaining water to the lime to make up five gallons, stir well and strain the milk of lime. The copper sulphate solution is then poured into the lime water, stirring the mixture well all the time.

***Observation.*—Bordeaux mixture deteriorates on keeping and so care should be taken to prepare only the quantity required for immediate use. It sometimes happens that unforeseen rains upset a day's spraying programme and a portion of the mixture prepared**

has to be left over for the next day. The mixture left overnight can be preserved by the addition of sugar or jaggery to it at the rate of ½ pound per 50 gallons of mixture.

II. *Lime Sulphur—Formula—*

Sulphur powder	10 pounds.
Lime	5 pounds.
Water	10 gallons.

Preparation.—Place enough water in the cooking vessel which may be of iron but not copper and add the lime. When the lime solution begins to boil add the sulphur little by little and keep stirring. Boil the mixture for about an hour over a gentle fire taking care to keep the level constant by adding more water till it assumes a chocolate colour. Strain off the sediment through a piece of coarse gunny. This is the stock solution which should be diluted with water for use.

Dilution.—Dilution of the stock solution is necessary before use. This depends on the polysulphide content. With home-made lime sulphur for spraying the freshly pruned stem or dormant trees, dilute the stock solution with 15 times the quantity of water and for foliage spraying with 25 parts of water.

N.B.—The mixture should never be overboiled or allowed to become green. Stock solut on may be preserved in air tight containers, a thin layer of kerosene oil on the top will preserve it from the action of air.

III. *Zinc Sulphate lime mixture* (10–5–100)—

Zinc Sulphate	1 pound,
Quick lime	½ pound.
Water	10 gallons.

Preparation.—Dissolve the zinc sulphate in five gallons of water, slake the lime by sprinkling water over it and when slaked, add enough water and stir well to make a thin paste and then make up the lime solution to five gallons with the remaining water and strain. Now, mix the zinc sulphate solution and the lime solution and stir vigorously.

This is not a fungicide. The mixture is effective against *mottle leaf* or *foliocellosis* of Citrus caused by zinc deficiency.

IV. *Bordeaux paste—Preparation.*—Dissolve 1½ lb. of copper sulphate in one gallon of water. Slake three pounds of quick lime and add one gallon of water and strain the milk of lime. Mix in equal parts.

This contains the same ingredients as Bordeaux mixture but water just sufficient to produce a thick paste. The paste may be painted with brush over wounds and cut surfaces of trees.

V. *Dry dressing of seed grains.*—The dual purpose of seed disinfection is to kill the disease inoculum on the surface of seed and to repel disease organisms in the soil around the seed.

Disinfectant chemicals are applied to seed in various ways. The older dip method is used for potatoes, ginger and for vegetables and flower seed. The seed is immersed in the chemical solution such as formaldehyde, mercuric chloride and copper sulphate solution of specified strength for a fixed period and then removed and dried.

The dusts are applied to small quantities of seed by shaking the seeds and dust for 10 to 15 minutes in a tin or other receptacle with an air tight lid. For larger quantities a simple home made seed dressing drum of convenient size can be made from an empty four gallon oil drum, three feet of $\frac{3}{4}$ inch iron piping, a small plank (baffle board) and two small hinges and a hasp. The machine may be mounted on a wooden stand or supported on two upright posts planted in the ground and provided with grooves on the top to hold the machine in position.

The following are some of the advantages of dry dressing, (i) that it can be applied dry, (ii) the treatment can be done at any time, (iii) the treated seeds can be stored for several months without fear of recontamination as the seeds are well covered over with the fungicides.

(1) *Sulphur treatment against grain smut* (Sphacelotheca sorghi) of cholam (Sorghum).—The sulphur should be very fine and should be thoroughly mixed with the seed so that each grain gets a uniform covering of the powder.

Rate : One ounce of sulphur for 15 lb. of sorghum seed.

(2) *Agrosan GN or Ceresan*.—Against seed borne diseases of rice like ' Foot rot ' (*Fusarium moniliforme*) and ' Helminthosporiose '.

Rate : One ounce for 30 lb. of seed.

N.B.—Agrosan GN and Ceresan are organo mercury compounds and are deadly poisons and so care should be taken to see that any surplus of treated grains is not used for human consumption or for feeding cattle.

Sprayers.—The spray fluid is best applied in the form of a fine uniform mist and for this reason it is applied with the aid of sprayers. Several types and designs of sprayers are in the market and it is often difficult for the ryot to select one which is most suited for his requirements.

The following points have to be considered in the choice of a sprayer; efficiency, cost, convenience in handling, simplicity in construction, durability, facilities for repairs and availability of spare parts. Sprayers range from the small hand atomiser, stirrup pump, knapsack type, barrel type to power sprayers. In our country the use of power driven sprayers has hitherto been limited to big estates and orchards where special crops are grown. Under the plant protection scheme, power sprayers are now kept at the district headquarters and supplied to the cultivators free of hire. They are charged only the actual cost of working and growers are now taking advantage of these facilities.

The Pests and Diseases Act.—Madras was the first State in India where control of plant diseases was sought to be effected with the aid of legislative enactments. The Pests and Diseases Act was put on the statute book in the year 1919. It is a comprehensive piece of legislation and enables the State Government to declare any pest, plant disease or noxious weed in a notified area to come under its purview and to take such measures as are deemed necessary for their effective control. The Act has been specially helpful in combating plant diseases which involve the removal and eradication of diseased plants which act as sources of infection and help in the spread of the disease. The provisions of the Act have been enforced in respect of various diseases from time to time and a short account of its working in respect of these diseases is given hereunder :—

(1) *Bud rot of palms.*—A disease of the palmyra (*Borassus flabellifer*), a tree of great economic importance in the Godavari delta was brought to the notice of the Government as early as the year 1904 as being responsible for the death of a large number of trees in the Godavari district. The disease was investigated by E. J. Butler then Imperial Mycologist in the Pusa Research Institute who found that the disease was caused by a fungus *Phytophthora palmivora.*

He found that in the majority of cases a tree once affected could not be saved and suggested as a means of combating the disease, the eradication of diseased palms which acted as sources of infection. His suggestions regarding control measures were accepted by the Government of Madras and a campaign was organised in 1906 and a special staff was appointed to carry out the measures in the infected areas. The staff did good work and a large number of diseased trees were operated upon and the infected crowns burnt. As the Pest Act had not yet been introduced the work was carried out chiefly through the tact and persuasiveness of the special staff. Inasmuch as the control measures were restricted to dead trees or inwardly infected plants no opposition was encountered from the cultivators who co-operated with the staff willingly. Subsequent investigation proved, however, that even apparently healthy trees and trees showing outward infection had also to be operated upon. This met with opposition from the owners and after experience of over fifteen years in the budrot campaign, the Pest and Diseases Act which was passed in 1919 was brought into force in respect of the palm disease in 1920. A special staff of the Revenue Department with an officer of the rank of a Deputy Collector was put in charge of the operations. The districts of East and West Godavari, parts of Guntur and Krishna districts were areas notified under the Act. A concentrated campaign was carried out with the aid of the Act and by 1930 the number of freshly infected trees was brought down to a negligible minimum and it was felt that the special campaign may be suspended.

The results of the campaign were, according to all reports, beneficial. The bulk of the infected trees were detected and operated upon and the number of new infections was gradually reduced.

The suspension of the campaign in 1930, however, proved to be based on a too optimistic assumption that the diseases had been brought under control, for in the succeeding year the disease gained the upper hand and in 1933 the recrudescence of the disease on an alarming scale necessitated the re-enforcement of the Pest Act and the organisation of the special staff once again. The special staff now appointed was, however, on a reduced scale in specified areas in the districts of East and West Godavari, Krishna and Guntur where the disease was rampant and the work has been carried on continuously ever since.

The recrudescence of the disease in the Circars after the suspension of the bud-rot campaign in 1930 emphasizes the need for continuous vigilance in the matter of the control of the bud-rot disease of palms in the northern districts.

In Malabar where the same disease on both the palmyra and coconut palm (*Cocos nucifera*) was noticed, action was taken in the year 1933 and the Pest Act has been in continuous operation ever since in some of the taluks of the district. Recently the Act has been extended to the entire South Malabar. As the area involved was comparatively smaller than in the Godavari Delta and the progress of the disease was not so rapid the special staff employed for the campaign was limited to two or three Revenue Inspectors and a technical subordinate belonging to the Agricultural Department.

In the earlier years of the campaign, owing to the inexperience of the revenue staff in this kind of work and the apathy of the owners who did not attach the same value to the palmyra palm, as their compeers in the Godavari delta did, progress was slow, and the proportion of the number of trees detected and operated upon by the Revenue Staff to the number actually diseased was low. But the economic importance of the disease in relation not only to the palmyra palm but also to the coconut palm was brought home to the revenue officials and the agricultural department took an active part in furthering the campaign. As a result of this concerted effort, there was gradual improvement in the quantity and quality of the work carried out by the special staff and the village officials. In recent years almost the entire area has been covered and most of the diseased trees have been operated upon. The number of fresh infections has been considerably reduced year by year and it can be confidently stated that the disease is being kept under control.

The failure in the working of the Pest Act in respect of the bud-rot of palms in one or two instances had been found to be due to the slackness of the revenue subordinates entrusted with the work and wherever this was rectified rapid improvement followed.

There is no doubt that the measures recommended by the original investigators have proved to be very successful in keeping down the disease and helped to save the palmyra industry from destruction in this State.

(2) *Sugarcane smut.*—The provisions of the Pests and Diseases Act have been applied in respect of the smut disease of sugarcane caused by *Ustilago scitaminea* in the Hospet taluk of Bellary district, from the year 1944. The disease has also been noticed to cause considerable damage in South Arcot and Chittoor districts. Though the disease has been prevalent in these areas for a long time, it is only recently that it has assumed dangerous proportions. The reasons for the increased importance of this disease are (1) the rapid increase in the area grown under sugarcane consequent on the establishment of sugar factories and (2) the practice of growing ratoons necessitated by economic considerations.

The disease is perpetuated by planting setts from diseased plants and spreads in the field from diseased to healthy plants by means of air-borne spores. Diseased plants in the field act as source of infection and prompt removal and destruction of such plants help in checking the spread of the disease. The Pest Act is enforced to have these measures carried out by the cultivators.

Though the experience in the working of the Act in respect of sugarcane smut is limited to a short period in a restricted area as compared to the working of the Act in respect of the bud rot of palms, the reports from the area show that the campaign has given beneficial results.

The difficulties of enforcing the provisions of the Act were found, in practice, to be considerably greater in respect of sugarcane smut than in respect of palmyra bud rot. Sugarcane fields lie scattered in the Hospet area and the location of infected plants involves careful search within the sugarcane field and their removal and destruction according to the prescribed methods (described elsewhere) could be carried out only with the active co-operation of the cultivators themselves. In the case of bud rot there had been 15 years of active campaign and propaganda relating to the disease in the Godavari and Krishna districts before the Pest Act was introduced and the ryots themselves were to a large extent co-operative and the penal provisions were seldom requisitioned for enforcing the Act. But in the case of sugarcane smut the enforcement of the Pest Act was a new experience both to the staff and to the cultivators. Notwithstanding these difficulties, some progress was made and the enforcement of the Act had its educative value in making the cultivators take a more active interest in the disease and inducing them to adopt measures for its control which would not have been possible otherwise.

(3) *Broom rape on Tobacco* (Orobanche cernua).—Orobanche is a harmful phanerogamic (flowering plant) parasite of tobacco. The rapid development of the Virginia tobacco industry in recent

years in the Guntur, Krishna and parts of Godavari districts led to an enormous increase in the area grown to tobacco year after year without any rotation of crops to check the multiplication of the parasite. The result was that parasite gained the upper hand and became a serious menace to the crop.

With a view to bring the parasite under control the provisions of the Pest Act were enforced in the districts of Guntur, Krishna and Godavari during the years 1941 to 1949. In order to effectively carry out the provisions of the Act in respect of this parasite a special staff under the control of a special District Agricultural Officer was employed for three years and the work was mainly carried out by them from 1944 to 1947.

The special staff covered all the important areas in the districts mentioned above, and with the co-operation of the revenue department enforced the provisions of the Act in compelling the cultivators to take measures for the eradication of the parasite. The measures consisted of periodical removal of the parasites as they appeared and burying them in pits sufficiently deep to prevent their further spread.

Though complete eradication of the parasite was not possible owing to the extensive area involved, the enforcement of the Act was beneficial in keeping the parasite in check to a great extent and in educating the cultivators in regard to the control measures against the parasite.

(4) *Wheat rusts.*—The Pest Act is in force in respect of these diseases throughout the State. The enforcement of the Act in respect of the rust disease of wheat was first done at the instance of the Indian Council of Agricultural Research in the years 1943–45 as an experimental measure to test the hypothesis of Dr. Mehta that the hills in South India act as reservoirs of inoculum for the rust diseases of wheat in the plains, especially the black rust (*Puccinia graminis tritici*) which is by far the most destructive. Dr. Mehta's hypothesis was based on his observations that in India, (1) Barberry (*Berberis vulgaris*) the alternate host of the rust fungus is not a factor in the dissemination of the disease as in other countries, (2) there is a longer interval between two successive crops of wheat in the plains during which summer intervenes when the temperatures in the plains of India are too high for the urediospores of the rust fungus to survive, and hence the possibility does not exist of the rust passing on directly from one crop to the succeeding one, and (3) in the hills of South India wheat is grown continuously throughout the year and consequently the initial inoculum for the spread of the disease should originate in the hills and get distributed by wind to the plains.

He, therefore, surmised that the prohibition of cultivation of the summer crop in the Nilgiris will break the continuity of the life-cycle of the fungus and result in considerably reducing the inoculum potential. And the enforcement of the Pest Act was directed towards this end. After a period of two years the Indian

Council of Agricultural Research abruptly terminated the scheme. During the year 1947 the question was re-opened and the provisions of the Act were once again enforced at the instance of the Central Government to cover the entire State.

It has been noticed, however, that the species of wheat normally grown on the hills of South India (*Triticum dicoccum*) is practically free from black rust and there is very little evidence to support the theory that it is chiefly responsible for the spread of the black rust disease. It has also been observed that there are a number of grasses on the Nilgiris which are recorded hosts of the fungus. Though the wheat crops on the hills were practically free from black rust, incidence of rust was noticed in the districts of Coimbatore and Bellary in the plains during the month of December by the officers deputed by the Directorate of Plant Protection to survey the disease in the year 1948. It would appear therefore that the hypothesis of Dr. Mehta is of doubtful validity and the prohibition of the summer crop would be of no help in so far as the black rust disease is concerned. It is a moot point whether this prohibition is to be continued to the detriment of a valuable food crop grown in the hills during the summer.

(5) *Cardamom mosaic.*—The Pest Act was first applied in respect of this disease in the year 1939 and has been in force ever since. The mosaic disease of cardamom is prevalent, all over the cardamom growing region in the South, but in one or two isolated areas like the Nelliampathis in Malabar, the disease has not yet been noticed. The application of the Pest Act in respect of this disease is directed towards the prevention of the transport of diseased planting material from the infected areas in the Anamalais to the Nelliampathy area. As the planters themselves take steps to see that infected material is not transported from one place to another the enforcement of the Act in the restricted area has not been difficult and the notification has been helpful in making the entire planting community aware of the need for such precautions.

Conclusion.—From the experience gained in the State in working the Pest Act, it can be stated that where the scientific basis of the suggested measures is sound and the enforcement is done in a methodical and systematic manner, beneficial results have been achieved.

DISEASES OF CULTIVATED PLANTS IN SOUTHERN INDIA.

Crop. (1)	*Disease.* (2)	*Causal organism.* (3)	*Distribution.* (4)	*Control measures.* (5)	*Remarks.* (6)
Allium cepa	Blight	*Alternaria palandui*	Coimbatore, Bellary and Nilgiris.	Spraying one per cent Bordeaux mixture as a preventive.	
Allium sativum.	Do.	*Do.*	Nilgiris and Kodaikanal (Madurai).	Do.	
Amaranthus spp.	White rust	*Cystopus bliti*	All over the State	....	Does not usually cause much damage.
	Foot rot	*Pythium aphanidermatum.*	Coimbatore	....	Minor disease.
Amorphophallus campanulatus.	Corm rot	*Sclerotium rolfsii*	Malabar and Circars.	....	
Ananas sativus	Fruit rot (Storage rot).	*Ceratostomella paradoxa.*	Malabar and South Kanara.	Smearing cut ends with an antiseptic (benzoic acid).	
Anona squamosa.	Pink disease	*Corticium salmonicolor*	Malabar	Pruning diseased branches and giving a bark wash with Bordeaux mixture.	
Arachis hypogaea.	Tikka disease	*Cercospora personata*	Throughout the State.	Spraying 4 : 4 : 50 Bordeaux mixture or dusting sulphur.	
	Root rot	*Macrophomina phaseoli.*	South Arcot and Guntur.	Seed selection.	
	Do.	*Sclerotium rolfsii*	Coimbatore and South Arcot.	....	
	Clump disease	Virus	Do.	(1) Roguing out diseased plants in the initial stages. (2) Thick sowing.	
Areca catechu.	Leaf spot	*Colletotrichum catechu*	Malabar, South Kanara and Coimbatore.	....	More a sign of weakened health of the trees. Manuring indicated.
	Bleeding	*Ceratostomella paradoxa.*	Do.	(1) Excision of affected part and painting with tar. (2) Preventing sun scorch of the stem.	

DISEASES OF CULTIVATED PLANTS IN SOUTHERN INDIA—*cont.*

Crop. (1)	*Disease.* (2)	*Causal organizm.* (3)	*Distribution.* (4)	*Control measures.* (5)	*Remarks.* (6)
***Areca catechu*—cont.**	Wilt	*Ganoderma lucidum*	Malabar, South Kanara and Coimbatore.	Eradication of affected palms and application of sulphur to the soil at the rate of half a pound per tree.	
	Mahali or Koleroga.	*Phytophthora palmivora.*	South Kanara and Malabar.	(1) Spraying bunches with one per cent Bordeaux mixture towards end of May and again July. (2) Eradication of bud rot affected palms.	
Artocarpus incisa.	Fruit rot	*Do.*	South Kanara	....	
Artocarpus integrifolia.	Pink disease	*Corticium salmonicolor*	Malabar	Pruning affected branches and protecting cut ends with Bordeaux paste.	
	Stem rot	*Fomes applanatus*	Do.	....	
	Leaf spot	*Glomerella artocarpi*	Coimbatore	....	Minor disease.
	Fruit rot	*Phytophthora palmivora.*	Malabar and South Kanara.	....	
	Inflorescence rot	*Rhizopus artocarpi*	Malabar, South Kanara and Coimbatore.	....	Affects usually male inflorescence.
	Root rot	*Rosellinia sp.*	Malabar and Nilgiris.	....	
Avena sativa	Rust	*Puccinia graminis avenæ.*	Nilgiris	Growing resistant varieties.	
	Smut	*Ustilago kolleri*	Do.	Seed dressing with organo mercury compounds.	
Beta vulgaris	Leaf spot	*Cercospora beticola*	Do.	Seed selection.	
	Heart rot	(Deficiency of boron)	Do.	Application of borax to the soil (5 lb. per acre).	
Borassus flabellifer.	False smut	*Graphiola borassi*	All over the State	....	Does not cause any damage.

	Bud rot	*Phytophthora palmivora.*	Circars and Malabar.	Removal of affected leaves in externally infected palms or cutting down the crown and destroying it in the case of internally affected palms.	
Brassica campestris.	Leaf spot	*Sphærodothis borassi*	Coimbatore	....	Minor disease.
	White rust	*Cystopus candidus*	Nilgiris	....	
	Water core	(Deficiency of boron)	....	Application of borax to the soil (5 lb. per acre).	
Brassica juncea.	White rust	*Cystopus candidus*	Coimbatore and Nilgiris.	....	
Brassica oleracea	Downy mildew	*Peronospora parasitica*	Nilgiris	....	
	Leaf spot	*Alternaria brassicæ*	Do.	Spraying Bordeaux mixture as a preventive.	
	Do.	*Mycosphalrella brassicæ.*	Nilgiris and Kodaikanal (Madurai).	....	
	Club root	*Plasmodiophora brassicæ.*	Nilgiris	Application of lime to the soil (1 to 2 tons per acre) and pouring half pint of 0·05 per cent mercuric chloride solution into the planting holes.	
Cajanus cajan	Wilt	*Fusarium udum*	Coimbatore and Guntur.	Growing resistant varieties, Green manuring with sunnhemp.	
	Mosaic	Virus	Coimbatore	Eradication of diseased plants in the initial stages.	
Camellia thea (Thea sinensis).	Sooty mould	*Asterina camelliæ*	Nilgiris and Coimbatore.	....	
	Root rot	*Botryodiplodia theobromæ.*	Do.		
	Red rust	*Cephaleuros parasitica*	In all planting districts.	....	
	Leaf spot	*Cercospora theæ*	Nilgiris and Coimbatore.	....	
	Pink disease	*Corticium salmonicolor*	Do.	Prunning affected branches and spraying Bordeaux mixture.	

Diseases of cultivated plants in Southern India—*cont.*

Crop. (1)	*Disease.* (2)	*Causal organism.* (3)	*Distribution.* (4)	*Control measures.* (5)	*Remarks.* (6)
Camellia thea (*Thea sinensi*) —cont.	Blister blight ..	*Exobasidium vexans* ..	Nilgiris, Coimbatore and Malabar.	Adjustment of pruning; reduction of shade and spraying Bordeaux or Burgundy mixture in the nurseries and worst affected portions.	
	Brown root disease	*Fomes noxius*	Nilgiris and Coimbatore.	Removal of affected plants.	
	Brown blight ..	*Glomerella cingulata* ..	Nilgiris and Malabar.	....	More a sign of nutritional defect.
	Grey blight ..	*Pestalozzia theae* ..	Nilgiris, Coimbatore and Malabar.	Application of manure.	
	Red root disease ..	*Sphærostilble repens* ..	Nilgiris	....	
	Stump rot	*Ustulina zonata* and *Rosellinia sp.*	Nilgiris, Coimbatore and Malabar.	Removal of affected plants.	
Capsicum annuum.	Fruit rot	*Colletotrichum capsici* ..	Coimbatore, Guntur, Tirunelveli, Madurai, Salem, Malabar and South Kanara.	Preventive spraying with one per cent Bordeaux mixture before the onset of the disease.	
	Blight	*Alternaria sp.*	Madurai	Spraying one per cent Bordeaux mixture.	
	Anthracnose ..	*Glomerella cingulata* ..	Coimbatore, Salem and Guntur.	Do.	
	Wilt	*Fusarium sp.*	Coimbatore	Drenching the soil round the plants with one per cent Bordeaux mixture.	
	Damping off ..	*Pythium aphanidermatum.*	Circars and Coimbatore.	Spraying the nursery with one per cent Bordeaux mixture once in ten days.	
	Mosaic	Virus disease	Guntur, Salem and Coimbatore.	....	
Canavalia ensiformis.	Leaf spot	*Cercospora cruenta* ..	Coimbatore	....	Minor disease.
	Rust	*Uromyces appendiculatus.*	Do.	....	

Carica papaya.	Damping off	*Pythium aphanidermatum.*	Do.	Drenching the soil with Bordeaux mixture at intervals.	
	Foot rot	*Do.*	Coimbatore, Salem and Madras.	Removal of affected parts and washing with Bordeaux mixture. Avoid planting by the side of water channels.	
	Fruit rot	*Gleosporium* sp.	Coimbatore	Spraying the fruit with Bordeaux mixture.	
	Leaf crinkle	Virus disease	Do.	Early eradication of affected plants.	
Carthamus tinctorius.	Leaf spot	*Cercospora carthami*	Coimbatore and Bellary.	Preventive spraying with Bordeaux mixture.	
	Blight	*Colletotrichum capsici*	Coimbatore	....	Minor disease.
	Rust	*Puccinia carthami*	Bellary	....	
Casuarina equisetifolia.	Wilt	*Trichosporium vesiculosum.*	Nellore, South Arcot, Tirunelveli and Tanjore.	Early eradication of diseased plants.	
Cenchrus ciliaris.	Smut	*Sorosporium cenchri*	Coimbatore and Tirunelveli.	Seed dressing with Ceresan.	
Chrysanthemum indicum.	Rust	*Puccinia chrysanthemi*	Coimbatore, Nilgiris and Madurai.	Dusting sulphur or spraying Bordeaux mixture.	
Chrysanthemum sinerarifolium.	Wilt	*Phytophthora cambivora.*	Madurai	....	
	Do.	*Rhizoctonia solani*	Do.	....	
	Damping off	*Pythium* sp.	Madurai and Nilgiris.	Drenching the soil in the nursery with Bordeaux mixture.	
Cicer arietinum.	Blight	*Colletotrichum capsici*	Coimbatore	....	
	Wilt	*Fusarium orthoceros* var *ciceri.*	Do.	Cultivation of resistant varieties.	
Cinchona officinalis and other spp.	Pink disease	*Corticium salmonicolor*	Anamalais	Pruning diseased branches and bark wash with one per cent Bordeaux mixture.	
	Collar rot and Canker.	*Phytophthora cinnamomi.*	Do.	Preventive spraying of the stem with one per cent Bordeaux mixture.	
	Damping off	*Pythium vexans*	Do.	Drenching the soil in the nursery with one per cent Bordeaux mixture.	
	Leaf spot	*Mycosphaerella theae*	Do.	....	Minor disease.

DISEASES OF CULTIVATED PLANTS IN SOUTHERN INDIA—*cont.*

Crop. (1)	*Disease.* (2)	*Causal organism.* (3)	*Distribution.* (4)	*Control measures.* (5)	*Remarks.* (6)
Cocos nucifera.	Stem bleeding ..	*Ceratostomella paradoxa.*	Circars, Tanjore, South Arcot, Tirunelveli, Coimbatore, and Malabar.	Excision of diseased parts and application of tar. Adequate manuring.	
	Root rot	*Ganoderma lucidum* ..	Coimbatore, Malabar and South Kanara.	Eradication of affected plants and application of sulphur to the soil (2 lb. per tree).	Green manuring is beneficial.
	Shoot and leaf rot.	*Gliocladium roseum* ..	Malabar	Pre-monsoon spraying of 1 per cent Bordeaux mixture and adequate application of potash manure.	
	Leaf spot	*Pestalozzia palmarum* ..	All over the State ..	....	Minor disease.
	Bud rot	*Phytophthora palmivora.*	Malabar, Coimbatore, Madras, South Kanara, and Circars.	Excision of affected leaf bases and removal of crown in the case of internally affected trees.	Protect surrounding trees by spraying Bordeaux mixture.
	Mahali or fruit rot.	Do.	Malabar and South Kanara.	Preventive spraying of the bunches with Bordeaux mixture.	
Coffea arabica.	Root rot	*Botryodiplodia theobromae.*	Nilgiris and Malabar ..	Adequate manuring.	
	Sooty mould ..	*Capnodium brasiliense* ..	Malabar, Nilgiris and Coimbatore.	....	
	Brown eye spot ..	*Cercospora coffeicola* ..	Malabar	Spraying with Bordeaux mixture.	
	Pink disease ..	*Corticium salmonicolor* ..	Malabar and Nilgiris.	Pruning diseased branches and spraying Bordeaux mixture.	
	Brown root disease.	*Fomes lamaoensis* ..	Do.	Eradication of affected plants.	
	Brown blight ..	*Glomerella cingulata* ..	Do.	Spraying Bordeaux mixture. Application of manures.	
	Rust	*Hemileia vastatrix* ..	Throughout South India.	Two sprays with ½ per cent Bordeaux mixture. Cultivation of resistant varieties (C. robusta).	

	Leaf spot	***Mycosphaerella coffeicola.***	**Nilgiris and Malabar.**	....	**Minor disease.**
	Black rot	***Pellicularia koleroga***	**Do.**	**Reducing shade and spraying bordeaux mixture.**	
	Stump rot	***Rosellinia* sp.**	**Malabar**	**Eradication of affected bushes and removal of neighbouring stumps.**	
	Do.	***Ustulina zonata***	**Do.**	**Do.**	
Coix lachryma-Jobi.	**Tar spot**	*Phyllachora coicis*	Do.	....	
	Rust	*Puccinia operta*	Do.	....	
Colocasia antiquorum.	**Leaf spot**	*Cercospora caladii* var. *colocasiae.*	Do.	....	
	Blight	*Phytophthora colocasiae.*	Malabar and Coimbatore.	....	
Coriandrum sativum.	Powdery mildew	*Erysiphe polygoni*	Tirunelveli	Dusting sulphur on foliage.	
Crotalaria juncea.	Wilt	*Fusarium vasinfectum*	Coimbatore and Tanjore.	....	
	Rust	*Uromyces decoratus*	Many districts	....	
Cucumis melo.	Powdery mildew	*Erysiphe cichoracearum.*	Cuddapah	Spraying 1 per cent Bordeaux mixture.	
	Downy mildew	*Peronoplasmopara cubensis.*	Do.	Do.	
Cucumis sativus.	Powdery mildew	*Erysiphe cichoracearum.*	Malabar	Spraying 1 per cent Bordeaux mixture.	
	Cottony leak	*Pythium aphanidermatum.*	Malabar and Coimbatore.	The fruit should not touch the soil.	
	Mosaic	Virus disease	Do.	Select seeds from healthy plants. Cut the affected vines and allow them to dry *in situ*.	
Cucurbita maxima.	Powdery mildew	*Erysiphe cichoracearum.*	In all districts	Spraying 1 per cent Bordeaux mixture.	
	Mosaic	Virus disease	Do.	Seed selection.	
Cuminum cyminum	Powdery mildew	*Erysiphe polygoni*	Ceded districts	Dusting sulphur.	
Curcuma longa.	Leaf spot	*Colletotrichum capsici*	Circars, Guntur, Coimbatore and Tiruchirapalli.	Preventive spraying with 1 per cent Bordeaux mixture.	
	Leaf blotch	*Taphrina maculans*	Circars	Do.	

DISEASES OF CULTIVATED PLANTS IN SOUTHERN INDIA—*cont.*

Crop. (1)	*Disease.* (2)	*Causal organism.* (3)	*Distribution.* (4)	*Control measures.* (5)	*Remarks.* (6)
Cyamopsis psoraloides.	Leaf spot	*Alternaria brassicae*	Coimbatore	Spray Bordeaux mixture if infection increases.	
	Wilt	*Fusarium* sp.	Do.	....	
	Powdery mildew	*Leveillula taurica*	In many districts	....	
Dioscorea sp.	Root rot	*Rhizoctonia bataticola*	Circars	....	
Dolichos biflorus.	Do.	Do.	Many districts	....	
Dolichos lablab.	Leaf spot	*Cercospora dolichi*	Do.	....	
	Powdery mildew	*Leveillula taurica* var. *macrospora.*	In several districts	Bordeaux mixture spray as a preventive.	
	Wilt	*Fusarium* sp.	Do.	....	
	Root rot	*Macrophomina phaseoli.*	Do.	....	
	Rust	*Uromyces appendiculatus.*	Coimbatore	....	
	Mosaic	Virus disease	In many districts	Seed selection and spraying insect repellents in the early stages of growth.	
Elettaria cardamomum.	Clump rot	*Pythium* spp.	In all planting districts.	Removal of affected shoots and application of ammonium phosphate (2—3 oz. per clump).	
	Mosaic	Virus disease	Do.	Eradication of diseased clumps propagation through seeds.	
Eleusine coracana.	Blight	*Helminthosporium nodulosum.*	All districts	Seed selection and disinfection.	
	Blast	*Piricularia* sp.	Do.	Early sowing may minimise infection.	
	Root rot	*Sclerotium rolfsii*	Coimbatore	....	
Fagopyrum esculentum.	Rust	*Puccinia fagopyri*	Nilgiris	....	
Ficus glomerata.	Rust	*Cerotelium fici*	In many districts	Dusting sulphur on the foliage or spraying with 1 per cent Bordeaux mixture.	
Fragaria sp.	Leaf spot	*Mycosphaerella fragariae.*	Nilgiris	Spraying 1 per cent Bordeaux mixture.	
Glycine soja	Rust	*Uromyces sojae*	South Arcot	....	

Gossypium arboreum.	Leaf spot	*Alternaria longipes* ..	Coimbatore	Spraying with 1 per cent Bordeaux mixture.	
	Wilt	*Fusarium vasinfectum* ..	Do.	Cultivation of resistant varieties.	
	Boll rot and seedling blight.	*Colletotrichum capsici* ..	Coimbatore, Tirunelveli and Bellary.	Seed treatment with Ceresan (1 gram per lb.).	
	Root rot	*Macrophomina phaseoli.*	All districts	....	
	Areolate mildew ..	*Mycosphaerella areola* ..	Many districts ..	....	
	Angular leaf spot ..	*Xanthomonas malvacearum.*	Coimbatore and Tirunelveli.	....	Minor disease.
	Little leaf (Stenosis).	Virus disease	Bellary and Coimbatore.	....	
G. hirsutum ..	Boll rot	*Aspergillus niger* ..	In many districts ..	....	Rare.
		Choanephora cucurbitarum.	South Arcot	....	Rare disease.
	Rust	*Cerotelium desmium* ..	Coimbatore	....	
	Root rot	*Macrophomina phaseoli.*	In all districts ..	....	
	Areolate mildew ..	*Mycosphaerella areola* ..	In many districts ..	....	
	Black arm	*Xanthomonas malvacearum.*	Do. ..	Seed treatment with Ceresan and cultivation of resistant varieties.	
Havea brasiliensis.	Root rot	*Botryodiplodia theobromae.*	Malabar	Improvement of soil conditions and manuring.	
	Anthracnose ..	*Colletotrichum heveae* ..	Do.	Spraying Bordeaux mixture.	
	Pink disease ..	*Corticium salmonicolor* ..	Do. .. .	Pruning affected branches and giving a bark wash with Bordeaux mixture.	
	Die back	*Diplodia* sp.	Do	Prune the affected branches and improve drainage.	
	Brown root disease.	*Fomes lamaoensis* ..	Do.	Eradication of affected roots.	
	Leaf spot	*Helminthosporium heveae.*	Do.	Spraying Bordeaux mixture.	
	Powdery mildew ..	*Oidium heveae*	Do.	Dusting sulphur.	
	Secondary leaf fall.	*Phytophthora palmivora.*	Do.	Spraying with Bordeaux mixture.	
	Red root disease ..	*Sphaerostilbe repens* ..	Do.	....	
	Stump rot	*Ustulina zonata*	Do. . ..	Removal of rotting stumps and affected trees.	
Hibiscus cannabinus.	Leaf spot	*Cercospora hibisci* ..	Circars	....	
	Root rot	*Macrophomina phaseoli.*	Do.	....	

DISEASES OF CULTIVATED PLANTS IN SOUTHERN INDIA—*cont.*

Crop. (1)	*Disease.* (2)	*Causal organism.* (3)	*Distribution.* (4)	*Control measures.* (5)	*Remarks.* (6)
Hibiscus esculentus.	Leaf spot ..	.. *Cercospora hibisci* ..	Coimbatore and South Kanara.	Spraying 1 per cent Bordeaux mixture.	
	Powdery mildew ..	*Erysiphe cichoracearum*.	Many districts ..	Dusting sulphur	
	Fruit rot ..	.. *Pythium indicum* ..	Coimbatore	Spraying Bordeaux mixture.	
	Vein clearing	.. Virus disease	In all districts ..	Repeated spraying of insect repellents from early stages of crop.	
Hordeum vulgare.	Blight ..	.. *Helminthosporium sativum.*	Nilgiris	....	
	Yellow rust	.. *Puccinia glumarum* ..	Do.	....	
	Black rust ..	.. *Puccinia graminis* ..	Do.	....	
	Smut ..	.. *Ustilago hordei*	....	Seed treatment with Agrosan GN 1 gram per lb.	
Indigofera sp.	Wilt ..	.. *Fusarium* sp.	Many districts ..	....	
Ipomoea batatas.	Leaf spot ..	.. *Cercospora batatas* ..	Coimbatore and Guntur.	....	
	Root rot ..	. *Macrophomina phaseoli*.	In many districts ..	Careful storage.	
	Do. ..	.. *Rhizopus nigricans* ..	Do. ..	Do.	
Jasminum spp.	Rust ..	.. *Puccinia chrysopogi* ..	Nilgiris and Salem ..	Removal of affected branches and dusting sulphur.	
	Do. ..	.. *Uromyces hobsoni* ..	Bellary	....	
Linum usitatissimum.	Wilt ..	.. *Fusarium lini*	Coimbatore	....	
	Rust ..	.. *Melampsora lini* ..	Do.	....	
Luffa acutangula.	Fruit rot ..	.. *Pythium aphanidermatum*.	Do.	....	Rare.
	Downy mildew	.. *Peronoplasmopara cubensis.*	Guntur	Spraying the foliage with 1 per cent Bordeaux mixture.	
Lycopersicum esculentum.	Early blight	.. *Alternaria solani* ..	Coimbatore and other districts.	Spraying the foliage with 1 per cent Bordeaux mixture.	
	Leaf mould	.. *Cladosporium fulvum* ..	Coimbatore	Do.	

	Wilt	***Fusarium bulbigenum*** ..	Many districts ..	Drenching the soil at the base of the plants with Bordeaux mixture.	
	Fruit rot	*Phytophthora palmivora.*	Coimbatore, Chingleput and other districts.	Spraying the plant with 1 per cent Bordeaux mixture at intervals. Avoid fruits contacting soil.	
	Damping off ..	*Pythium aphanidermatum.*	Circars and Coimbatore.	Spray nursery with 1 per cent Bordeaux mixture once a week.	
	Leaf spot	*Stemphylium solani* ..	Tanjore and Guntur.	Spray 1 per cent Bordeaux mixture.	
	Spotted wilt ..	Virus disease	Coimbatore and Tanjore.	Roguing in the initial stages.	
	Big bud	Do.	Coimbatore	Seed selection and roguing.	
	Little leaf	Do.	Coimbatore and Guntur.	Roguing.	
Mangifera indica.	Sooty mould ..	*Capnodium mangiferae* ..	All districts	Spray fish oil resin soap to destroy insects.	
	Anthraenose ..	*Colletotrichum gloeosporioides.*	Malabar and other districts.	Spray young fruits with 1 per cent Bordeaux mixture.	
	Pink disease ..	*Corticium salmonicolor* ..	Malabar and South Kanara.	Prune diseased branches and give a bark wash with 1 per cent Bordeaux mixture.	
	Canker and die back.	*Diplodia* sp.	Malabar, Tanjore and Madurai.	Prune diseased branches, application of manures.	
	Powdery mildew ..	*Oidium mangiferae* ..	Coimbatore, Salem, Malabar, North Arcot and Chittoor.	Dusting sulphur on the flowers.	
	Sooty blotch ..	*Rhinocladium corticolum.*	All districts	....	Does not cause damage.
	Grey blight ..	*Pestalozzia mangiferae* ..	Guntur	....	
Manihot utilissima.	Leaf spot	*Cercospora henningsii* ..	Malabar and Coimbatore.	....	Minor disease.
	Root rot	*Phytomonas sp.*	Malabar	....	
	Leaf crinkle ..	Virus disease	Coimbatore	Eradication of affected plants.	
Maranta arundinacea.	Banded leaf blight.	*Pellicularia filamentosa.*	Malabar	Preventive spraying with 1 per cent Bordeaux mixture.	

DISEASES OF CULTIVATED PLANTS IN SOUTHERN INDIA—*cont.*

Crop. (1)	*Disease.* (2)	*Causal organism.* (3)	*Distribution.* (4)	*Control measures.* (5)	*Remarks.* (6)
Medicago sativa.	**Wilt**	*Fusarium* sp.	Coimbatore and Salem.	....	
	Root rot	*Macrophomina phaseoli.*	Coimbatore	....	
	Leaf spot	*Pseudopeziza medicaginis.*	Do.	....	
	Rust	*Uromyces striatus*	In many districts	....	
Moringa oleifera.	**Foot rot**	*Diplodia* sp.	Krishna and Coimbatore.	....	
Morus alba	**Powdery mildew**	*Phyllactinia corylea*	Coimbatore, Nilgiris and Guntur.	Adjustment of pruning time and spraying lime sulphur.	
Musa paradisiaca.	**Shoot rot**	*Ceratostomella paradoxa.*	Krishna	....	Minor disease.
	Leaf spot	*Cordana musae*	Coimbatore	....	
	Wilt	*Fusarium oxysporum*	Vizagapatnam, Godavari, Madurai, Coimbatore, Salem and Malabar.	Selection of suckers for planting and eradication of affected plants.	Only a few varieties are susceptible in South India.
	Anthracnose	*Gloeosporium musarum.*	Circars and Tanjore	Preventive spraying of bunches with 1 per cent Bordeaux mixture.	
	Black tip	*Helminthosporium torulosum.*	Coimbatore	....	Minor disease.
	Black finger	*Macrophoma musae*	Many districts	Spray the bunches with 1 per cent Bordeaux mixture after removing the affected fruits.	
	Shoot rot	Bacterial disease	Salem	Eradication of diseased clumps and selection of healthy suckers for planting.	
Nicotiana tabacum.	**Frog eye sopt**	*Cercospora nicotianae*	Circars, Salem, Coimbatore and Madura.	Spray the plants in the early stages with colloidal copper; seed treatment with 1 per cent silver nitrate solution.	

	Powdery mildew ..	*Erysiphe cichoracearum.*	Salem, Coimbatore and Madurai.	Apply sulphur to the soil round the plants, wide spacing, pruning of lower leaves.	
	Black shank ..	*Phytophthora palmivora.*	Salem, South Arcot and Coimbatore.	Apply 1 per cent Bordeaux mixture down the stem to drench the soil; avoid over irrigation.	
	Damping off ..	*Pythium aphanidermatum.*	Circars and Coimbatore.	Apply 1 per cent Bordeaux mixture once a fortnight at 500 gallons per acre from the twentieth day of sowing.	
	Black leg	*Xanthomonas solanacearum.*	Salem	....	
	Broom rape ..	*Orobanche cernus* ..	All districts	Practice three year rotation and grow chillies before tobacco.	
	Mosaic	Virus disease	Do. . ..	Roguing, careful handling of crop and observance of sanitary principles.	
	Leaf curl	Do.	Do.	Do.	
	Frenching	Deficiency disease ..	Guntur	Proper manuring especially organic nitrogen.	
	Sand drown ..	Magnesium deficiency ..	Coimbatore	Application of manures containing magnesium salts.	
Oryza sativa ..	Leaf spot	*Cercospora oryzae* ..	Do.	....	Very minor disease.
		Curvularia lunata ..	Coimbatore, Tirunelveli and Tanjore.	....	Minor disease affecting glumes.
	Oodhu batti disease.	*Ephelis oryzae* (*Balansia oryzae*).	Kollegal (Coimbatore), Kurnool and Wynaad (Malabar).	....	Minor disease.
	Helminthosporiose.	*Helminthosporium oryzae.*	All over the State ..	Seed dressing with Agrosan GN or ceresan 1 gm per lb. of seed.	
	Stem Rot	*Leptosphaeria salvinii* (*Sclerotium oryzae*).	Tanjore, Tiruchirappalli, Krishna, Coimbatore and Malabar.	Drain off water and keep the soil muddy.	Infects plants weakened by other causes.
	Leaf spot	*Nigrospora sphaerica* ..	All over the State ..	...	Very minor disease does not cause damage.

DISEASES OF CULTIVATED PLANTS IN SOUTHERN INDIA—*cont.*

Crop. (1)	*Disease.* (2)	*Causal organism.* (3)	*Distribution.* (4)	*Control measures.* (5)	*Remarks.* (6)
Oryza sativa—cont.	Blast ..	.. *Piricularia oryzae* ..	Tanjore, Madurai, Chingleput. Coimbatore, Chittoor, Nellore, Circars, Malabar and South Kanara.	Cultivation of resistant strains like CO 4, CO 25, & CO 26.	
	Foot Rot ..	.. *Gibberella fujikuro* (*Fusarium moniliforme* var. *majus*).	Krishna, Vizagapatnam, Godavari, Coimbatore, Trichirappalli, Tanjore, South Arcot, Madurai and Ramanathapuram.	Seed dressing with organic mercury compounds 1 gm per lb. of seed.	The disease is slowly extending to other districts.
	Bunt ..	.. *Neovossia horrida* ..	Malabar and Guntur.	....	Minor disease.
	Stack burn	.. *Trichoconis caudata* ..	Tirunelveli, Tanjore and Coimbatore.	....	Do.
	False smut	.. *Ustilaginoidea virens* ..	All over the State ..	....	Do.
	Sheath rot ..	.. *Pellicularia filamentosa.*	Malabar	....	Do.
	Root Rot ..	.. *Pythium* sp.	Malabar and Tanjore.	Application of balanced manure.	Do.
Panicum frumentaceum (Echinochloa verona var. frumentacea).	Smut ..	.. *Ustilago panicifrumentacei.*	Coimbatore and Godavari.	....	
	Do. ..	.. *Ustilago paradoxa* ..	Do.	....	
Panicum miliaceum.	Do. ..	.. *Sphacelotheca destruens.*	Do.	....	
Panicum miliare.	Rust ..	.. *Uromyces linearis* ..	Coimbatore	....	
Paspalum scrobiculatum.	Smut ..	.. *Sorosporium paspali* ..	Coimbatore, Madurai, Tanjore and Guntur.	Seed dressing with Agrosan GN.	
Pennisetum typhoides.	Leaf spot ..	.. *Acrothecium penniseti* ..	Coimbatore	....	
	Rust ..	.. *Puccinia penniseti* ..	All districts	....	
	Downy mildew	.. *Sclerospora graminicola*	Do.	....	
	Smut ..	.. *Tolyposporium penicillariae.*	Do.	....	

Phaseolus mungo.	Root Rot ..	.. *Macrophomina phaseoli.*	Coimbatore and Tanjore.	....	
	Leaf spot ..	.. *Cercospora cruenta* ..	Coimbatore	....	
	Rust ..	.. *Uromyces appendiculatus.*	Do.	....	
Phaseolus radiatus.	Leaf spot ..	.. *Cercospora cruenta* ..	Do.	....	
	Root Rot ..	.. *Macrophomina phaseoli.*	Do.	....	
Phaseolus vulgaris.	Anthracnose	.. *Colletotrichum lindemuthianum.*	Nilgiris, Madurai and Salem.	Seed selection and seed treatment with organo mercury compound 1 gm. per lb.	
	Rust ..	.. *Uromyces appendiculatus.*	Nilgiris and Madurai.	....	
hoenix sylvestris.	Smut (false)	.. *Graphiola phoenicis* ..	Many districts ..	....	Does not cause damage.
	Bud Rot ..	.. *Phytophthora palmivora.*	Circars	....	
Phyllanthus distichus.	Rust ..	.. *Phakopsora phyllanthi* ..	Many districts ..	....	
Phyllanthus emblica.	Rust ..	.. *Ravenelia emblicae* ..	Coimbatore, Madurai, and Malabar.	....	
Piper betle ..	Leaf spot ..	.. *Colletotrichum piperis* ..	In many districts ..	Spray ½ per cent Bordeaux mixture on the stem and leaves.	Sign of old age.
	Powdery mildew ..	*Oidium piperis*	Do. ..	Dusting sulphur on the foliage.	
	Wilt ..	.. *Phytophthora palmivora.*	Madras, Chingleput, Tanjore, Vizagapatnam and Coimbatore.	Drench the soil and base of vines with Bordeaux mixture (2–2–50) once in two months.	
	Root Rot ..	.. *Sclerotium rolfsii* ..	Madras, Chingleput, Tanjore and Visakhapatnam.	Removal of diseased plants and drenching soil and base of stem with ½ per cent Bordeaux mixture.	
	Leaf Spot ..	.. Bacterial disease ..	Many districts ..	Plant sanitation.	
Piper nigrum.	Pollu ..	.. *Colletotrichum necator* ..	Malabar	....	
	Root Rot ..	.. *Diplodia sp.*	Do.	....	
	Wilt ..	.. *Pythium sp.*	Do.	....	
		Rhizoctonia solani ..	Do.	....	
	Stump rot ..	.. *Rosellinia bunodes* ..	Do.	....	
Pisum sativum.	Leaf spot ..	.. *Ascochyta pisi*	Nilgiris	Spray bordeaux mixture ..	
	Powdery mildew ..	*Erysiphe polygoni* ..	Nilgiris and Madurai ..	Dusting sulphur.	
	Rust ..	.. *Uromyces fabae*	Nilgiris	Do.	

DISEASES OF CULTIVATED PLANTS IN SOUTHERN INDIA—*cont.*

Crop. (1)	Disease. (2)	Causal organism. (3)	Distribution. (4)	Control measures. (5)	Remarks. (6)
Prunus armeniaca.	Die back	*Botryosphaeria ribis* ..	Nilgiris	Pruning diseased branches and applying bark wash with 1 per cent Bordeaux mixture.	
Prunus domestica.	Rust	*Tranzschelia pruni-spinosae.*	Do.	....	
	Witches broom ..	(Manganese deficiency).	Do.	Spray 0·2 per cent manganese sulphate solution on foliage.	
Prunus persica.	Leaf curl	*Taphrina deformans* ..	Nilgiris and Madurai ..	Pruning affected branches and spraying the trees with 1 per cent Bordeaux mixture.	
	Rust	*Tranzschelia prunis-pinosae.*	Nilgiris	....	
Psidium guajava	Sooty mould ..	*Meliola* sp.	All districts	Spraying fish oil resin soap (5 lb. in 100 gallons of water).	
	Anthracnose ..	*Gloeosporium* sp. ..	Do.	Spraying 1 per cent Bordeaux mixture.	
	Fruit spot	*Pestalozzia psidii* ..	Do.	Do.	
Punica granatum.	Leaf and fruit rot.	*Mycosphaerella lythracearum.*	Coimbatore and Madurai.	Spraying the leaves and fruits with 1 per cent Bordeaux mixture.	
Pyrus communis.	Fruit rot	*Glomerella cingulata* ..	Nilgiris	Removal of all cankered branches, mummified fruits and spraying 1 per cent Bordeaux mixture.	
	Canker	*Diplodia* sp.	Do.	Removal of cankered branches, and protective bark wash with 1 per cent Bordeaux mixture.	
Pyrus malus ..	Die back	*Botryosphaeria ribis* ..	Do.	Pruning away diseased branches and bark washing with 1 percent Bordeaux mixture.	

	Pink disease	*Corticium salmonicolor*	Do.	Removal of affected branches 12" below infection and washing bark with 1 per cent Bordeaux mixture.	
	Bitter rot	*Glomerella cingulata*	Do.	Removal of mummified fruits and cankered branches and spraying 1 per cent Bordeaux mixture.	
	Powdery mildew	*Podosphaera leucotricha.*	Do.	Dusting sulphur.	
Raphanus sativus.	Leaf spot	*Alternaria brassicae*	Coimbatore and Nilgiris.	Spraying foliage with 1 per cent Bordeaux mixture.	
	White rust	*Cystopus candidus*	Many districts	....	
	Downy mildew	*Peronospora parasitica*	Coimbatore and Nilgiris.	Spraying foliage with 1 per cent Bordeaux mixture.	
Ricinus communis.	Leaf spot	*Cercospora ricinella*	Many districts	....	
	Die back	*Diplodia ricinicola*	South Arcot	....	
	Powdery mildew	*Leveillula taurica*	Many districts	....	
	Rust	*Melampsora ricini*	Do.	....	
	Leaf blight	*Phytophthora palmivora*	Coimbatore	Spraying the plants with 1 per cent Bordeaux mixture.	
	Seedling blight	*Pythium aphanidermatum.*	Do.	Do.	
Rosa sp.	Leaf spot	*Diplocarpon rosae*	Chingleput, Nilgiris, Coimbatore and Madurai.	Spraying the foliage with 1 per cent Bordeaux mixture.	
	Powdery mildew	*Sphaerotheca pannosa*	Many districts	Dusting sulphur on the foliage.	
Rumex vesicarius.	Rust	*Puccinia nepalensis*	Coimbatore	....	
Saccharum officinarum.	Rind disease	*Diplodia sp.*	Many districts	....	Affects old cane.
	Wilt	*Cephalosporium sacchari.*	South Arcot	Selection of setts.	
	Red rot	*Colletotrichum falcatum (Physalospora tucumanensis).*	Many districts	Selection of healthy setts, dipping setts in Bordeaux mixture before planting.	
	Collar rot	*Hendersonina sacchari*	South Arcot	Selection of setts for planting.	

DISEASES OF CULTIVATED PLANTS IN SOUTHERN INDIA—*cont.*

Crop. (1)	*Disease.* (2)	*Causal organism.* (3)	*Distribution.* (4)	*Control measures.* (5)	*Remarks.* (6)
Saccharum officinarum—cont.	Ring spot	*Leptosphaeria sacchari*	Many districts	....	Minor disease.
	Top rot	*Fusarium moniliforme*	South Arcot, Tiruchirappalli and Coimbatore.	....	Do.
	Rind disease	*Pleocyta sacchari*	Coimbatore	....	Affects old canes.
	Sett rot	*Ceratostomella paradoxa.*	Many districts	Dipping setts in 1 per cent Bordeaux mixture before planting.	
	Seedling blight	*Pythium graminicolum*	Coimbatore	....	
	Root rot	*Pythium* sp.	Do.	Balanced manuring, avoidance of excess of nitrogen.	
	Smut	*Ustilago scitaminea*	Many districts	Eradication and destruction of sori, removal of affected clumps, selection of setts and avoidance of ratooning.	
	Striga	*Striga euphrasioides*	Do.	Spray Agroxone or Fernoxone (0·2 per cent).	
	Mosaic	Virus disease	Do.	Selection of setts, roguing and cultivation of resistant varieties.	
	Streak	Do.	Coimbatore	Do.	
Secale cereale	Ergot	*Clavice as purpurea*	Nilgiris	....	Artificial infecton only.
	Rust	*Pucciniagraminis secalis.*	Do.	....	
Sesamum orientale.	Blight	*Alternaria sp.*	Coimbatore	....	
	Leaf spot	*Cercospora sesami*	Coimbatore, Madurai and Ceded districts.	....	
	Root rot	*Macrophomina phaseoli*	Coimbatore	....	
	Powdery mildew	*Oidium sp.*	Many districts	....	
Setaria italica.	Blast	*Piricularia setariae*	Coimbatore	....	
	Downy mildew	*Sclerospora graminicola.*	Many districts	Eradication of affected plants.	

	Rust	*Uromyces setariae-italicae.*	Do.	Early sowing and cultivation of resistant varieties.	
	Smut	*Ustilago crameri*	Ceded districts	Seed treatment with sulphur (1 oz. per 15 lb. of seed).	
Solanum melongena.	Leaf spot	*Cercospora solani*	Many districts	....	
	Powdery mildew	*Leveillula taurica*	Do.	....	
	Wilt	*Fusarium* sp.	Do.	Drench soil with 1 per cent Bordeaux mixture.	
	Rust	*Puccinia penniseti*	Coimbatore and Salem.	....	
	Cottony leak of fruits.	*Pythium aphanidermatum.*	Coimbatore	The fruits should not touch the soil.	
	Damping off	Do.	Circars	Drench the soil with Bordeaux mixture once in 10 days.	
	Little leaf	Virus disease	Many districts	Roguing in the early stage of disease.	
Solanum nigrum.	Leaf spot	*Cercospora solanacea*	Do.	Spray the foilage with 1 per cent Bordeaux mixture.	
Solanum tuberosum.	Early blight	*Alternaria solani*	Nilgiris	Spraying the foliage with 1 per cent Bordeaux mixture one month after emergence and again three weeks later.	
	Leaf spot	*Cercospora concors*	Kodaikanal (Madurai) and Guntur.	Spraying Bordeaux mixture.	A minor disease.
	Black scurf	*Corticium solani*	Nilgiris and Guntur (Probably introduced into latter district from the former).	Seed selection and steeping seed tubers in acidulated 0·1 per cent corrosive sublimate.	
	Powdery scab	*Spongospora subterranea.*	Nilgiris	Seed selection and crop rotation, green manuring application of organic manures.	Minor disease.
	Dry rot	*Fusarium coeruleum*	In storage on the Nilgiris.	Observe sanitary methods of storage.	
	Ring disease	*Pseudomonas solanacearum.*	Do.	Seed selection and crop rotation.	
	Mosaic	Virus disease	Nilgiris	The use of certified seed	
	Leaf roll	Do.	Do.	Do.	
	Aucuba mosaic	Do.	Do.	Do.	Minor disease.

DISEASES OF CULTIVATED PLANTS IN SOUTHERN INDIA—*cont.*

Crop. (1)	*Disease.* (2)	*Causal organism.* (3)	*Distribution.* (4)	*Control measures.* (5)	*Remarks.* (6)
Solanum tuberosum—cont.	Crinkle	Virus disease	Nilgiris	The use of certified seed	
	Black heart	Physiological disease	In the plains districts (Storage disease).	Improvement of ventilation in potato stores and in transit wagons. Provision of cold storage.	
Sorghum vulgare.	....	*Cerebella sorghi vulgaris.*	All districts	Occurs only on grains affected by sugary disease.	
	Leaf spot	*Cercospora sorghi*	All over the State	....	
	Anthracnose	*Colletotrichum graminicolum.*	Do.	....	Rarely causes appreciable damage.
	Leaf spot	*Curvularia lunata*	Coimbatore	....	
	Leaf stripe	*Helminthosporium turcicum.*	All over the State	....	
	Rust	*Puccinia purpurea*	Do.	....	
	Downy mildew	*Sclerospora sorghi*	Do.	Eradication of affected plants.	
	Sugary disease	*Sphacelia sorghi*	All over the State affecting the rabi crop.	Avoidance of late sowing of July–August crop.	
	Sooty blotch	*Titaeospora andropogonis.*	Guntur and Coimbatore.	....	
	Loose smut	*Sphacelotheca cruenta*	Coimbatore, Salem, Madurai and Ceded districts.	Seed dressing with sulphur one oz. per 15 lb. seed.	
	Grain smut	*Sphacelotheca sorghi*	All over the State	Do.	
	Head smut	*Sphacelotheca reiliana*	Do.	Eradication of affected plants.	
	Long smut	*Tolyposporium ehrenbergii.*	Coimbatore, Ramanathapuram, Tirunelveli and Madurai.	....	Minor disease.
	Mosaic	Virus disease	Coimbatore	Roguing	
	Leaf stripe	Do.	Do.	Do.	
	Twisted top	*Fusarium moniliforme*	Coimbatore and Tiruchirapalli.	....	Minor disease.

Tectona grandis.	Rust	*Chaconia tectonae* ..	Malabar and Coimbatore.	....
	Powdery mildew ..	*Uncinula tectonae* ..	Do.	....
Trichosanthes anguina.	Do. ..	*Erysiphe cichoracearum.*	Many districts ..	Dusting sulphur .. ..
	Fruit rot	*Pythium aphanidermatum.*	Do. ..	Spraying Bordeaux mixture and keeping the fruit away from soil.
Triticum dicoccum.	Yellow rust ..	*Puccinia glumarum* ..	Nilgiris and Palnis ..	....
	Brown rust ..	*Puccinia triticina* ..	Many districts ..	....
	Black rust	*Puccinia graminis* ..	Coimbatore, Bellary and Guntur.	....
	Leaf spot	*Septoria tritici*	Nilgiris	....
	Loose smut ..	*Ustilago tritici*	Do.	Solar treatment drying soaked seeds in hot sun for eight hours.
Triticum vulgare.	Yellow rust ..	*Puccinia glumarum* ..	Nilgiris	....
	Black rust	*Puccinia graminis* ..	Nilgiris and Coimbatore.	....
	Brown rust ..	*Puccinia triticina* ..	Do.	....
	Leaf spot	*Septoria tritici*	Nilgiris ..	....
	Loose smut ..	*Ustilago tritici*	Do.	Soaking seeds in water and drying in hot sun.
Vicia faba ..	Powdery mildew ..	*Erysiphe polygoni* ..	Nilgiris and Palnis ..	Dusting sulphur .. ..
	Rust . ..	*Uromyces fabae*	Do. ..	Do. ..
Vigna catjang.	Anthracnose ..	*Colletotrichum lindemuthianum.*	Coimbatore	Seed selection and seed treatment.
	Wilt	*Fusarium sp.*	Do. ..	....
	Root rot	*Macrophomina phaseoli.*	Do. ..	....
	Powdery mildew ..	*Erysiphe cichoracearum.*	Many districts ..	Dusting sulphur if warranted.
	Rust	*Uromyces appendiculatus.*	Do. ..	....
Vitis vinifera ..	Leaf spot	*Cercospora vitis* . ..	Malabar and Coimbatore.	Spraying one per cent Bordeaux mixture.
	Anthracnose ..	*Elsinoe ampelina (Gloeosporium ampelophagum).*	Salem, Madurai and Coimbatore.	Periodical spraying with 1 per cent Bordeaux mixture.
	Downy mildew ..	*Plasmopara viticola* ..	Do.	Do.

DISEASES OF CULTIVATED PLANTS IN SOUTHERN INDIA—*cont.*

Crop. (1)	*Disease.* (2)	*Causal organism.* (3)	*Distribution.* (4)	*Control measures.* (5)	*Remarks.* (6)
***Vitis vinifera*—cont.**	Powdery mildew ..	*Uncinula necator* ..	Anantapur, Salem, Coimbatore and Madurai.	Periodical spraying with 1 per cent Bordeaux mixture.	
	Rust ..	*Cerotelium vitis* ..	Coimbatore and Nilgiris.	Dusting sulphur	
Zea mays ..	Leaf stripe ..	*Helminthosporium turcicum.*	Many districts ..	....	
	Rust ..	*Puccinia sorghi* ..	Coimbatore, Nilgiris and Madura.	....	
	Downy mildew ..	*Sclerospora maydis* ..	Coimbatore	....	
	Smut ..	*Sphacelotheca reiliana* ..	Do. ..	....	
Zingiber officinale.	Leaf spot ..	*Phyllosticta zingiberi* ..	Godavari and Malabar.	Spraying the foliage with 1 per cent Bordeaux mixture.	
	Rhizome rot ..	*Pythium aphanidermatum.*	Malabar	Steeping seed rhizomes in 0·1 per cent mercuric chloride solution for 1½ hours before storage.	
	Do. ..	*P. myriotylum*	Do.	Do.	
	Do. ..	*P. vexans*	Do.	Do.	

CHAPTER 24.

NUTRITION.

Animal nutrition—Production value of feeds—Digestibility co-efficients—Requirements of protein for different conditions and fixing up of rations—Nitrogen, carbon and mineral balance experiments—Feeding standards—Protein metabolism and muscular work—Mineral metabolism studies on lactating cows and growing calves—Pasture survey of Madras—Mineral composition of pasture grasses—Fluorosis, its causes, symptoms and ameliorative measures—Poultry nutrition—Wool production in sheep—Nutritive value of crops as affected by manuring—Use of small animals for nutritional studies—Utilization of molasses—Silage investigations—Protein reduction and carbohydrate increase in diet—Improving palatability of coarse strains—Treacle as a diet for farm animals—Improving breeding bulls by a change of diet—Human nutrition—Malting trials—Analytical data on vegetables and fruits.

Introduction.—Nutrition work on human beings as well as on farm animals has reached very high levels in countries like America, Britain, Germany, Russia and Japan. In this country, the Nutrition Institute at Coonoor has been doing work on human nutrition for the last thirty years. As far as animal nutrition is concerned, some experiments on the digestibility of Indian fodders by Lander in the Punjab and by Warth at Bangalore mark the early attempts in this field. It is to the credit of the Madras Government that Animal Nutrition studies were started for the first time in India in Madras. The experiments which were located at Coimbatore under the control of the Government Agricultural Chemist, commenced in 1926 with some preliminary studies. From 1928, more elaborate work was undertaken and during a period of five years sufficiently encouraging results were obtained. The Indian (then Imperial) Council of Agricultural Research sanctioned a scheme for the extension of the work for the first instance for a period of five years from 1933, later extended till 1943.

During the last 25 years, therefore, different aspects of Animal Nutrition have thus been studied by the Government Agricultural Chemist and some valuable information obtained. The problem of human nutrition does not strictly come under the purview of the Government Agricultural Chemist. But, off and on, wherever the occasion arose, several lines of investigation relating also to human nutrition have been carried out by him as independent items of research. In this chapter it is proposed to give an account of all these items of work.

Animal nutrition.—What may be called Nutrition experiments were first started on the Central Cattle Farm, Hosur in Salem district to solve some specific questions. The experiments were by

no means up to date nor could they be called scientific. There was no proper equipment in the earlier years, and some of the experiments were conducted by the Deputy Director of Livestock, at the Military Dairy, Bangalore. Amongst several trials may be mentioned three, (1) to see if rice bran could be included with benefit in a cow's ration, (2) to see if silage could be substituted for green fodder and (3) to get information on the prejudice held by the milkmen of Madras against groundnut cake as a food for the milch cow.

Although some information was available from these experiments, systematic studies were started only in 1926, when the technical help of the Government Agricultural Chemist was also sought to run nutrition experiments on proper lines.

What may be called the forerunner of Animal Nutrition studies done by the Department, was an experiment conducted in 1926 on the production values of different feeds. The experiments were under the control of the Government Lecturing Chemist but the animals for the experiment were chosen by the Deputy Director of Livestock and throughout the conduct of the experiments there was close co-operation between the two officers.

Production values of feeds—Experiments.—Six heifers of the cross bred Bangalore herd nearly alike in physical condition and ranging in age from 21 to 23 months, were selected for the experiments. The ration given was 6 lb. concentrate and 40 lb. of green fodder. The concentrates included groundnut cake and rice bran 2 lb. each, and cotton seed and dholl husk at 1 lb. each. Six weeks after the start of the experiments, the concentrate was increased by half a lb. of groundnut cake. The object of the experiment was to determine the production value of the feed, by which is meant the gain in weight made by the animals with a given ration during a specified time.

The results showed that 11·72 lb. of dry matter was required by a heifer of two years to produce 1 lb. increase in weight. It was also seen that heifers with Nellore blood seemed to put on weight faster than those of the Sindhi cross and that large sized animals seemed to put on better weight than small sized ones. It was further indicated, that, the greater the capacity of the animal to consume roughage the greater was the weight put on.

Along with the determination of the production values, the digestive co-efficients of the rations used were also determined. This was done by carefully collecting, weighing and analysing the dung excreted by the animals during the period of the experiments. Similarly the food taken was also carefully weighed and analysed. From the total food ingested and the dung excreted and the analytical data, what are known as the "digestibility coefficients" of the different nutrients were calculated. The following figures were thus obtained.

Digestibility coefficient.—Ration 6½ lb. concentrate 40 lb. green fodder.

Nutrient in the ration.	*Digestibility coefficient (percentage).*
Protein	79·68
Fat	64·72
Fibre	28·80
Carbohydrate	60·61

Requirements of proteids for different conditions and the fixing up of rations.—It was in 1928 that systematic experiments were started, with all necessary precautions in specially constructed stalls and with the required staff and equipment. The first problem studied was the determination of the extent to which the more commonly used feeding stuffs like cholam and paddy straw, oil cakes, cotton seed and brans were digested by farm animals. Based on the results it was proposed to fix rations suited to the type and condition. The problem of maintenance ration for a work bullock, i.e., the amount of roughage and concentrates which could maintain in condition an animal at rest was considered to be the fittest for the initial study. This is the foundation on which additional rations can be superimposed according to the nature of the work the animal is expected to perform, over and above maintenance.

Experiments were conducted with sorghum (*Chitrai cholam*) straw as the roughage and groundnut cake as the concentrate on six Ongole bullocks. The first ration consisted of 6·82 kilograms (about 15 lb.) of *Chitrai cholam* straw and 0·9 kilogram (about 2 lb.) of groundnut cake per day per animal. Based on American standards this ration was admittedly high for maintenance, but it was considered safe to start with a high ration initially and then go down by slow steps to the plane of nutrition required for maintenance. As a matter of fact after about two months, the ration was brought down to 0·6 kilogram of groundnut cake; the experiment was continued for nine months during which five rounds of estimations of digestibility coefficients were also done. The following were the average figures during these five rounds.

Digestibility coefficients—Average of five rounds.—Ration : **15 lb. cholam straw, 2 lb. groundnut cake.**

Name of nutrient.	*Per cent digested.*
Dry matter	**53·44**
Protein	**60·94**
Fat	**64·87**
Fibre	**66·89**
Carbohydrate	**42·93**
Mineral matter	**39·29**

These figures, being the averages of five rounds, are more reliable than those obtained in 1926 in connection with the production value experiments. It would be seen that the protein digested in the ration supplied is about 61 per cent.

During the experiment an interesting observation was made. The live weights of the animals were steadily increasing. This could be due to only one of two reasons, either that the animals were still growing or that the ration fed was too large for maintenance. Since the animals had been selected very carefully before the experiments and by all signs were quite mature, the only possibility was that the ration fed was too high.

Nitrogen balance experiment.—A nitrogen balance experiment is a further advance on the technique followed for determining digestibility coefficient. In a digestibility experiment the dung alone is collected, weighed and analysed on the assumption that the solid excreta represents the portion of the food that has been left undigested by the animal. In a nitrogen balance experiment the urine is also taken into consideration and from analytical data pertaining to the ration supplied, the dung voided and the urine excreted, it is possible to strike a balance sheet and say whether an animal is receiving enough or more or less nitrogen than it requires. With the ration given to these animals, namely, 6·82 kilograms sorghum straw and 0·6 kilogram of groundnut cake, it was found that the animals were in positive nitrogen balance. In other words, the amount of nitrogen that was supplied by the ration was more than could be accounted for by that found in the urine and the dung. This extra nitrogen formed new tissues in the body and thus the animals increased in weight. The ration supplied was therefore higher than the maintenance ration.

The next step taken consisted in cutting out the concentrated altogether and keeping animals entirely on sorghum straw. The amount of straw fed was also increased to twice the original rate so that the animals could eat as much straw as they liked. It was found that on a purely straw diet like this there was a negative nitrogen balance and the animals began to lose weight. The conclusion was that roughage fed in the form of sorghum fodder is not sufficient to meet the requirements of resting Catabolism in a mature Ongole bullock 1,000 lb. live weight even though it is fed straw *ad libitum*. With the information available on the amount of nitrogen deficit on a pure straw diet, proteid (groundnut cake) was slowly introduced into the diet until the nitrogen balance was neither positive nor negative and the animals did not gain or lose in weight. When such a result was obtained, the amount of groundnut cake included in the ration to achieve this end, was expressed in terms of protein. Further, a figure was calculated as the digestible proteid with the data already obtained, namely, 61 per cent digestibility coefficient of protein. As a result of these studies, it was established that the level of portein requirement in the form of groundnut cake for bullocks at rest is in the

neighbourhood of 100—150 grms. of available protein. This figure is the maintenance requirement of protein for the working bullock.

Requirements for light, medium and heavy work.—In the next set of experiments, an attempt was made to find the requirements for different kinds of work in addition to rest. The animals were made to do different kinds of work like—light, medium heavy and very heavy. Under these different conditions nitrogen balance experiments were conducted and protein requirements were calculated. The criteria on which these distinctions were based were as follows :—

(1) Light work.—Hauling a cart 1,000 lb. weight on a level road at three miles per hour for four hours.

(2) Medium heavy work.—Mhoting for four hours on a ramp one in 30 at about 30 buckets per hour, each bucket containing 45 gallons of water.

(3) Very heavy work.—Mhoting for eight hours.

With groundnut cake and sorghum straw as the ration supplied the requirements of work bullocks at rest and under different classes of work were found to be as follows :—

Requirements of groundnut cake and sorghum straw for work bullocks.

Nature of work.	*Groundnut cake required in lb.*	*Sorghum straw required in lb.*
Rest	0·20	17
Light work	1·00	17
Medium heavy work	1·50	17
Heavy work	2·00	17

In terms of digestible portein supplied by this ration, the requirements were therefore approximately 100 grms. for rest, 300 grms. for light work, 450 grms. for medium heavy and 600 grms. for very heavy work.

One interesting observation elucidated during these experiments is worth emphasising at this stage. Armsby, working in America had found that American animals required very much more digestible portein for these different conditions. Armsby's figure for maintenance requirement was roughly 300 grms. digestible protein. This is the figure for light work requirement in the Coimbatore experiment. This shows that Indian bullocks, as typified by the Ongole breed, are economic consumers of food.

Experiments with Kangayam bullocks.—The next set of experiments conducted was with some animals of the Kangayam breed. With these animals also the maintenance requirement was about 100 grms. digestible protein. But, for light work and for heavy work the requirements were less than that for the Ongole breed being 150 grms. for light work and 200 grms. for heavy work. While therefore confirming the results of the previous experiments for maintenance requirements, the results indicated

that the Kangayam bullocks can be maintained at even less expense than the Ongole. It was also noted that work does not increase the digestibility co-efficient of any particular nutrient, although the quantity of food taken in was more.

Different sources of protein supply.—The next stage in the experiment was an alteration in the source of protein supply. While straw continued to be the roughtage, cotton seed was included in the ration instead of groundnut cake. The results obtained confirmed the previous conclusions that the maintenance requiremnts for an animal of 1000 lb. live weight was again 100 grms. digestible protein. Indirectly it was also established that protein could be supplied either as cake or as cotton seed, although a larger quantity of cotton seed had to be fed than the groundnut cake. In further trials, '*Irungu cholam*' *fodder* and '*Peria-manjal cholam*' fodder were used as roughages and these were found to have the same digestibility as rice straw.

Feeding standards.—Sufficient information had now been obtained with these feeding stuffs available at Coimbatore. The next step, therefore, was the formulation of feeding standards for work bullocks based on the results of these experiments. With rice straw and sorghum straw as roughages and a variety of concentrates to supply digestible proteins, rations on a "Slab system" for rest, light work and heavy work, were fixed up. These rations were then advocated for trial at the several Agricultural Research Stations for working bullocks. Reports from 23 such stations showed that the proposed rations were suitable and did not result in any untoward effect on the animals. In some research stations, however, there was a practical difficulty felt in deciding the intensity of work and the ration suitable for it. Standards for the slabs like hauling a cart, or mhoting for four and eight hours could not be reproduced at all stations. Further, it was seen that heavier animals of the Ongole breed fell off in their weights with the ration advocated by the Chemist which was based on work with Kangayam bullocks. A revised system of ration was therefore recommended reducing the four slabs, maintenance, light work, medium heavy work, and very heavy work to three slabs, namely, maintenance, medium and heavy work. This revised slab was more practical to follow as maintenance was equivalent to being tied in the stall without work; very heavy work was equivalent to continuous ploughing or mhoting for eight hours and all other operations could be taken as medium work. In addition to this revised slab system, it was also recommended that a flat rate increase of half pound concentrate be included to all heavy animals. Before the introduction of the slab system the rations followed at the Agricultural Research Stations were very much higher than that recommended by the Agricultural Chemist. One important result of this experimental work was therefore a reduction in the cost of maintenance.

It must, however, be stated that the results were obtained at Coimbatore with Kangayam bullocks, under the conditions existing there. More detailed investigation was necessary at the different Agricultural Research Stations, with feeding stuffs available in the locality with animals of the tract and with the conditions of work obtaining there. In general, the observations so far available confirm the finding that the existing rations in the different localities are too high and that the Chemist's ration is efficient and economical.

Protein metabolism as affected by muscular work.—With the protein requirements for various conditions determined and confirmed, an attempt was made to find a correlation between the quantum of work done and the quantum of protein supplied. It was noticed during the Coimbatore experiments on protein requirements for different conditions that muscular work resulted in an increased output of urinary nitrogen. This meant that muscular work resulted in a heightened protein catabolism.

The actual experiments were done with four bullocks of the Kangayam breed of as similar physical conditions as possible with live weights ranging from 900—1,000 lb. The ration fed consisted of sorghum straw of uniform quality and cotton seed as the concentrate. The roughage was fed *ad libitum*, but the concentrate fed was adjusted by some preliminary nitrogen balance experiments. The muscular work performed during the experiment was baling water at the mhote for a measured number of hours, the number of buckets raised per hour being recorded and the lift being 25 feet for 40 gallon buckets. The different periods studied were four hours, six hours, and eight hours of work. From the result obtained regression equations of the following types were possible:—

(1) ($Y = 4{\cdot}79\,x + 46{\cdot}7$ where) Y was the total nitrogen requirement and X was the number of hours at work.

While this was the equation obtained for the total n itrogen catabolised (i.e., dung plus urine) an examination of the urinary nitrogen also gave a similar equation. We have already seen that the dung nitrogen represents the undigested portion of the food and the urinary nitrogen the digested portion. The urinary nitrogen is thus a measure of work done in terms of what is known as the "Endogenous Nitrogen output". The actual equation obtained for the urinary nitrogen was—

(2) $Y = 2{\cdot}56\,x + 16{\cdot}6$ where Y was the urinary nitrogen and X the number of hours of work at the mhote.

The results expressed by these mathematical equations can now be summarised as follows:—(1) Muscular work is necessarily followed by an increase in protein metabolism. (2) The quantum of dietary protein required at different levels of work is a linear function of the quantum of work performed. (3) The quantum of protein metabolised is also a linear function of the quantum of work performed.

In other words, the more muscular the work the more is the protein metabolised in the body and the more is the protein in the diet taken. It was actually found that for eight hours mhoting the protein requirement was 500 grms. and for six hours mhoting it was 400 grms.

These experiments indicate, therefore, that when an animal is doing extra work a greater protein catabolism results. Therefore, sufficient protein must be included in the diet to allow for this extra protein catabolism; otherwise the animal will meet the requirement by a break-down of its tissue proteins and lose weight. It was actually found that for every increment in work of two hours, 5 grms. of dietary protein was required.

Studies of mineral metabolism in Farm animals—Minerals in nutrition.—In addition to the carbohydrates, fats, and proteins, minerals also play an important part in the nutrition of farm animals. From the fact that bones contain a large percentage of tricalcium phosphate, it is generally known, even amongst laymen, that sufficient amounts of calcium and phosphorous must be included in the diet. With the starting of animal nutrition experiments at Coimbatore and the study of protein requirements for different levels of work, an opportunity occurred to gather data on mineral requirements as well. What was required was a set of experiments in which the food given to the animals and the excreta voided, should be analysed for mineral contents and the balance struck as was done for nitrogen in the experiments for protein requirements.

The early experiment on minerals in nutrition was started as a preliminary enquiry and was stimulated by an article by Theiler in the British Journal of Agricultural Science in the year 1928 In that article the author had mentioned that the inclusion of a small quantity of bonemeal in the diet of farm animals reduced incidence of disease and mortality and increased the fertility of cows. It was therefore considered that a systematic experiment should be done under Coimbatore conditions to get some information on the value of bonemeal.

With the co-operation of the Deputy Director of Agriculture, Livestock, mixtures of bonemeal and lime were fed to calves and to cows which had to take repeated service before they conceived. The Deputy Director of Livestock reported that good results were achieved by including the mixture of bonemeal and lime in the ration. The next step was a regular feeding experiment on some young calves. Twelve calves were selected of both sexes. These were divided into two groups of six each so that the total live weights of the two groups were equal and each group consisted of equal number of calves of both sexes. One of these groups received minerals in addition to the ration, while the other groups received only the normal ration. Live weights were recorded

periodically of the animals in both the groups. At the start of the experiments the mean live weights of the mineral group was 305 lb. while that of the non-mineral group was 309 lb. This difference was kept up till the 15th week when the minerals were 418 lb. and non-minerals were 417 lb. live weight. From the 15th week onwards there was a steady increase in body weight and at the end of the 35 weeks the mineral group animals had outstripped the animals of the other group recording a mean live weight of 541 lb. as against 521 lb. of the " non-mineral group ". In addition to the proof given by the actual weights the calves receiving minerals were also looking decidedly better than the non-mineral group. It was first established that the inclusion of bonemeal and linc in the ration definitely improved the live weight and condition of growing calves. The experiments on calves were closed in 1930, as a number of the heifers had become pregnant but in the meanwhile under a scheme sanctioned by the Imperial (now Indian) Council of Agricultural Research in 1935, systematic studies were started on mineral metabolism of farm animals

Mineral metabolism experiments—(*a*) *Heifers*.—The experiments were done with two groups of animals, group (a) on heifers and group (b) on cross bred cows. Experimental animals of group (a) were six Kangayam heifers. They were studied for their mineral metabolism by the usual method of working out a balance sheet for lime and phosphoric acid. The rations fed were the usual dairy rations fed at the Coimbatore College Dairy graded for live weight and for age and included one ounce of mineral mixtures containing equal quantities of shell lime and bonemeal. The animals were in the second and third year during the experiment representing a period of adolescence. During the first year seven metabolism experiments were carried out on these animals. The results of the first experiment indicated that with the ration supplied the heifers were in negative calcium balance. For the remaining six experiments, therefore, the quantity of mineral mixture fed was increased from one ounce to two ounces per animal per day. The composition of mineral mixture was also altered to contain three parts of shell lime to two of bonemeal. This change resulted in a heightened plane of calcium metabolism and in a positive calcium balance during the remaining experiments. The general conclusion drawn from these experiments was that for growth and pregnancy, Kangayam heifers require lime and phosphoric acid of the order of 35 g rms. per day per animal.

The experiments were continued till 1941. While the conclusions drawn in the first year were generally confirmed, as the heifers became cows and started yielding milk, the results were erratic probably because Kangayam cows were poor milk yielders. There was, therefore, not much drain evidently and whether in lactation or dry or pregnant the animals continued to show the same requirement for calcium and phosphoric acid.

(*b*) *Cross-bred cows.*—The experiments with cross-bred cows gave, however, more definite information with a correlation between mineral requirement and the yield of milk. The results generally showed that in cross-bred cows a heavy milk yield is associated with a negative calcium balance, although the phosphoric acid was positive. The indication was, therefore, that the requirement of dietary calcium of a cow in heavy milk is more intense than its requirements for dietary phosphorous. In the case of cows yielding 15 to 20 lb. milk and more per day, even a change in the composition of mineral mixture increasing the proportion of shell lime to bonemeal did not correct the negative balance for calcium. The experiments on the cross-bred cows were also continued for nearly five years and throughout the period a positive corelation between mineral requirement and the quantum of milk was obtained. The following table summarises the requirements as elucidated by these experiments :—

Requirements of calcium and phosphoric acid for Dairy Animals.

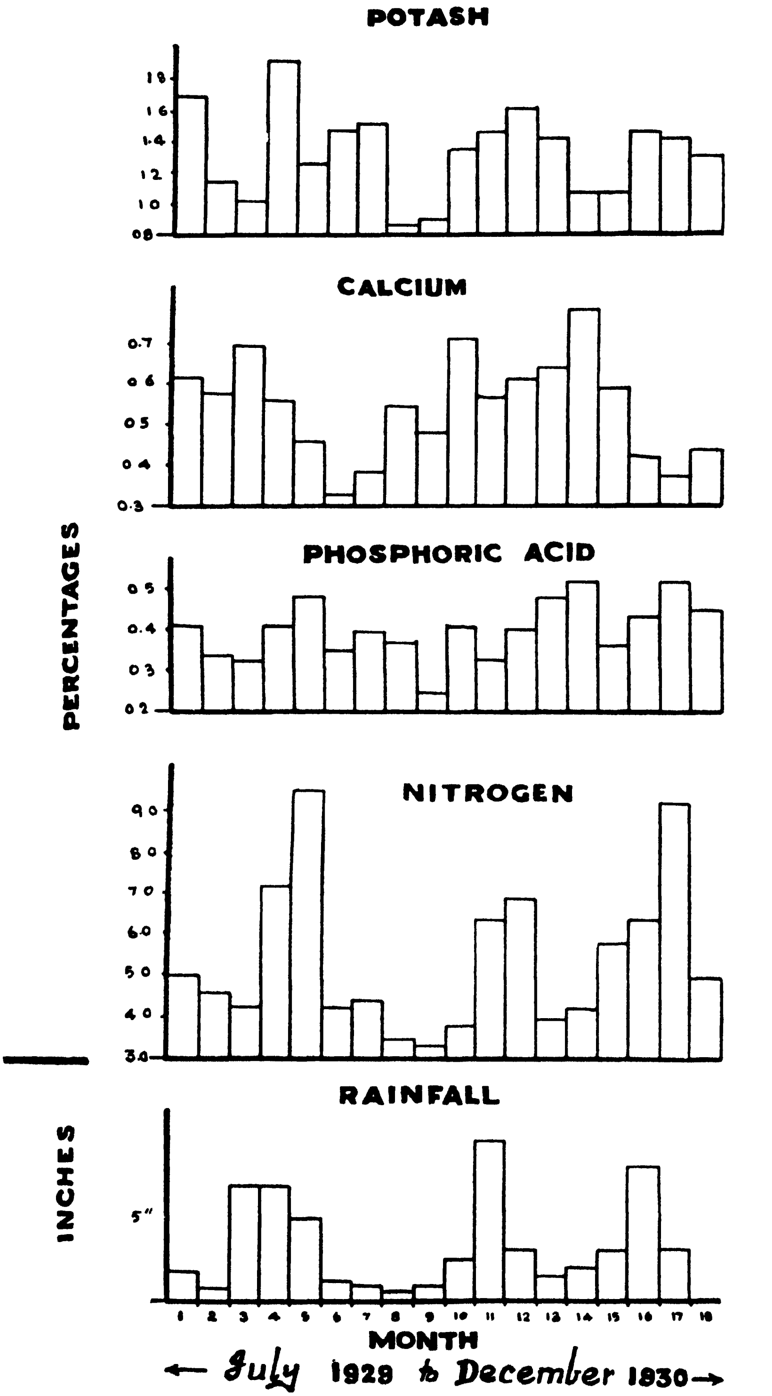
Stage of animal.	*Requirement of lime per day in grms.*	*Requirement of phosphoric acid per day in grms.*
Young growing heifers	40	25
Pregnant heifers	40	25
Cows in heavy milk	75	50

These are the figures obtained with cross-bred cows. With Kangayam animals the requirements were lower. It was noted during these experiments for studies of this kind, that Kangayam animals were not suitable. Not only were they poor in milk yield but most of them did not conceive after service and proved disappointing. On the other hand cross-bred animals were extremely suitable. They showed a steady increase in calcium requirement with growth, and during pregnancy and this requirement increased still further after parturition and lactation. During 1933 and 1934, an attempt was made to replace the bonemeal of the mineral mixture with flour phosphate obtained by powdering Trichinopoly phosphates. The flour phosphate was treated with bacterial culture before being made into mixture. The results, however, were not so encouraging as bonemeal.

For working bullocks also one oz. of mineral mixture is fed mixed with the concentrated ration as a daily routine in all Agricultural Research Stations of the State, and this, besides rectifying mineral deficiency, acts as a prophylaxis against stiff joints and other common ailments associated with bullocks.

The practical importance of these mineral metabolism experiments is illustrated in that to-day the inclusion of mineral mixture is followed as a routine operation for the dairy animals in all the

Seasonal variation in Minerals and Nitrogen of spear grass



Government Farms. A definite recommendation that two oz. of the mineral mixture should form part of the diet of calves and lactating animals has been made.

The pasture grasses of the State—Their mineral composition and value in nutrition.—It was reported in the previous section that experiments indicated the need for including lime and phosphoric acid in adequate amounts in the rations of growing calves and cows in milk. While stall fed animals can always be fed a mineral supplement as a daily routine, the problem becomes a little more complicated with animals depending entirely or partly on pasture. Pasture grasses are known to be rich in mineral matter, although there is much variation from species to species and form area to area. In some localities the pastures contain only one particular species predominantly, while in others it is a mixed herbage that is available for grazing.

The first investigation of pasture grasses done by the Madras Agricultural Department was a study of the seasonal variation in the mineral and nitrogen content of spear grass (*Andropogan cartroltus*) at the Livestock Research Station, Hosur.

Samples of this grass were collected every month and analysed for original moisture, total ash, silica, calcium, phosphoric acid, potash and proteins. The work was started in 1929 and was continued for 18 months, samples being taken every month from four different paddocks. The mean obtained for each of these 18 months is shown in a chart wherein the seasonal variations are clearly seen along with rainfall. (Chart.)

It would be seen from this chart (i) that there is well defined seasonal tide in the variation of all the constituents, (ii) that the nitrogen and phosphoric acid curves were parellel while the calcium content varied inversely as the nitrogen and phosphoric acid; the peak of the curve for nitrogen and phosphoric acid coincides with rainfall, and (iii) in general, the pastures at Hosur showed no definite sign of deficiency in any of the minerals, though, in certain seasons from December to March, the phosphoric acid and the lime are a little low.

Along with the analysis of the grass the soils of the paddock were also examined. Though there was no apparent correlation between the minerals in the soils and the herbage, it was generally seen that the soils of Hosur were poor in lime and phosphoric acid. A mathematical examination of the analytical data revealed a positive correlation between phosphoric acid and nitrogen and were suggestive of a close connection between nitrogen and phosphoric acid in the matabolic processes of the plant.

Apart from the data provided for the seasonal variations, the investigation threw some light on the mineral content of the herbage of natural grasses during their life cycle. With figures available for other countries, a short note of comparison would prove interesting. As regards calcium, the content was quite high during dry seasons reaching the value nearly equal to that of a British pasture. During the wet season the value fell and there was a shortage of calcium. As this is the main grazing season, a shortage of calcium during this period is a disadvantage. As regards phosphoric acid, the value at no time reached that of good pastures in other countries, being particularly low in the dry months. This indicates that animals in this pasture would not be receiving sufficient phosphates. Potash was also low compared with other good pastures, but this is not a very serious defect, because excessive potash owing to its diuretic effect is not a very desirable factor, especially in tracts where drinking water is scarce.

The practical significance of the results obtained during the investigation can be summed up. The best period for moving for silage or hay-making is when the grasses flowered and before the seeds have set. This practice would conserve maximum of protein and phosphoric acid. Actual analysis indicated that nearly 50 per cent of the phosphoric acid was lost in the process of hay-making. This is possibly due to two causes, one the lower nutritive value of the dead ripe grass and the loss of seed material by combing. It is unfortunate that the maximum content of phosphoric acid and nitrogen coincides with the period of heaviest rainfall when conditions are not favourable for hay-making. Either artificial curing during the wet weather has to be done or growth must be rushed up with ammonium sulphate application to escape rain. The making of silage from immature grass which has not yet become ripe is a usual practice at Hosur and the resulting produce is of high nutritive value as compared to the poor quality of the dead ripe grass.

To young stock and animals even when they are grazing the feeding of mineral supplement was indicated.

Pasture survey.—Analysis of grasses in and around Coimbatore on the same lines as was done with the spear grass at Hosur was being done by the Government Agricultural Chemist during the years 1930–36. Some preliminary information was made available as a result of these analysis and it was felt that a systematic study of the grasses in the pastures of the whole Madras State must be done. To do this a scheme was sanctioned by the Indian Council of Agricultural Research in 1936 as one of the items of work of the Animal nutrition experiments at Coimbatore. Samples of grass were collected from the different localities and were brought to Coimbatore where the Government Systematic Botanist helped to identify the different specimens and worked out the percentages of the different species. The samples were then analysed for their moisture, ash, lime, phosphoric acid, potash and nitrogen. During

a period of five years almost all the districts were visited like this and analytical data on the pasture grasses of the State were available. From these data pasture maps of the State were drawn similar to the soil survey maps mentioned in an earlier chapter. The map shows clearly the areas of sufficient and deficient minerals in the pastures of Madras State. It also enables us to correlate the growth of cattle in a particular locality with pasture composition and to suggest ways and means for improving the cattle.

One other fact which emerged during the course of this pasture survey was a phytogeographic distribution of pasture grasses in different localities. There were certain zones which seem to be adopted for particular species. For example in the Circars the predominant type is *Chengaligaddi* (*Icelyme laxum*). In the Kangayam area of Coimbatore district *Kolukettai* grass (*Cenchrus ciliaris*) overgrows any other species. In Hosur and Salem the spear grass (*Andropogan contrortus*) is prominent. The *Hariali* (*Cyanodon dactylon*) seems to be a cosmopolitan, but even this prefers certain areas to others. For example in the Tiruthani taluk of Chittoor district this is the most important fodder grass of the tract. The analytical data revealed wide variation in the sample from different localities, the ranges being, one per cent to 21 per cent ash; 4 to 17 per cent protein, 0·3 to 1 per cent of calcium and 0·2 to 0·8 per cent phosphoric acid. In general, pastures from deltas, South Arcot, Ramnad, Coimbatore, Salem, and portions of Nellore were high in proteins, phosphoric acid and lime. Anantapur, Malabar and South Kanara were districts with pasture grass of very poor quality. In the remaining areas of the State the pasture grasses are of average composition. In some portions of Nellore pasture with very low phosphate content was also found associated with the incidence of fluorosis.

During the pasture survey of the grasses of Madras to assess the mineral content, it was noticed that cattle of certain tracts were subject to a peculiar malady, characterised by bone-malformation, stiffness of joints, lameness and other symptoms associated with " *Osteomalacia* ". Enlarged hoofs and nodular formations on the ribs and other bones were other characteristic symptoms. All these were known to be due to " fluorosis " a disease known to be prevalent in human beings and cattle and is due to ingestion of fluorine along with the food.

The affected areas were mainly in Kurnool district and in certain parts of Nellore. With the aid of a scheme sanctioned by the Indian Council of Agricultural Research a detailed investigation was undertaken to study the etiology and pathogenesis of the disease and, if possible, to suggest remedial methods to cure or control it.

Altogether 98 villages were visited in Ceded Districts and Nellore and records made of the prevalence of the disease, its characteristic symptoms and variations in its severity from locality to locality. While in most, of the villages visited, fluorosis in more or less

aggravated form was noted, there were some in which the disease was altogether absent. It was also recorded that affected animals from other villages got cured in course of time if taken and kept in the curative villages.

Fluorosis in human beings and cattle has been traced to drinking water, phosphate containing mineral supplements to food, forage crops treated with fluorine containing insecticides and similar other sources of fluorine. An analysis of the drinking water from the wells and tanks of these areas was therefore taken up with particular reference to the fluorine content. The water from affected villages showed a fluorine content ranging from one to four parts per million while in the curative villages the fluorine content in the water examined was less than 0·5 part per million.

An analysis of the rocks, minerals and soils of the area also showed that in the affected areas the geological formation was a permanent source of supply to the waters flowing over them. Thus while the fluorine in the water was the immediate cause of the disease, it could be traced ultimately to the underlying rock formations, particularly to the granites and gneisses of an unclassified type, found in the Kurnool area.

Apart from the drinking water, other causes either as sources of fluorine or contributing in some other way, were also examined. Groundnut haulms is an important part of the ration for the animals of this tract and there was an opinion that feeding of these was responsible for the incidence of the disease. An examination of the haulms did not however, support the popular opinion, the nutritive value of the haulms being quite high. The fluorine content of the haulms was also negligible and not sufficient to warrant for the disease and incidentally it was noted that it was the spreading variety that had more fluorine than the bunch variety.

While the analysis thus ruled out the groundnut haulms as the source of fluorine, another constituent namely, phosphoric acid showed significant differences in its total amount. The Ceded districts haulms had very low phosphoric acid content, while haulms from Tindivanam, where there is no fluorosis, showed a high percentage of this constituent.

In Kurnool, a permanent source of supply emits from the rocks, minerals, soils and drinking waters, and the mineral matabolism of the animals is upset by the imbalance between calcium and phosphoric acid and this makes the animal susceptible.

This line of argument was sought to be confirmed by an examination of the phosphorous level in nutrition. The blood from healthy animals as for example, from Coimbatore showed the inorganic phosphorus to be four to five milligrams per 100 c.c. of the blood, a normal figure reported elsewhere also. When the blood of animals from the affected areas in Kurnool was examined, it was found that the blood contained only one to two milligrams of phosphorus per 100 c.c. This low blood phosphorus is an index

of deficient phosphorus nutrition. This results in aphosphorosis and is one of the major causes for the severity of the disease in Kurnool area. If this view is correct supplementing the ration with adequate amounts of phosphoric acid might well be considered as one of the ameliorative measures.

An actual experiment with animals was then taken up to obtain information on this aspect. Six calves of nearly the same age and physical condition were selected for the experiment and divided into three groups as follows :—

Group I.—To receive half a lb. each of groundnut cake, cotton seed, and rice bran and *dhall* husk and sufficient rice straw as also one ounce of bone meal supplement.

Group II.—Same ration as above, but with fluorine in the form of sodium fluoride given as drench, every morning before feed.

Group II.—Same ration as above, but with fluorine in the supplement.

It would be seen that group I, which does not get any fluorine in its feed, but is liberally supplied with rations and minerals is the control. Group III, will show the effect of adding fluorine to the diet, while the animals of group II will prove whether by the inclusion of a bone meal supplement, the incidence of the disease is either averted or stopped altogether.

Periodical live weights and other observational notes were maintained on the animals. The animals of the first group did not show any symptoms of fluorosis at all; the other two groups developed symptoms within two months and the effects were accelerated in group III. The experiment thus demonstrated that the inclusion of bone meal could not stop the disease but that it could alleviate the conditions somewhat.

Detailed laboratory examinations revealed that the blood of the animals in the different groups did not show any difference in calcium or phosphoric acid or even fluorine. On the other hand, fluorine was found to be deposited on the bones. Post-mortem examination showed that the vital organs kidneys, liver and spleen were shrunk and reduced in size. By conducting balance experiments and analysing feed, urine and dung it was established that the fluorine was mostly excreted through the dung and to a little extent by the urine. It was also found that a daily dosage of three to six milligrams of fluorine per kilogram of body weight, was enough to produce active symptoms in the course of two months. When dosage was increased from seven to 18 milligrams the symptoms set in much earlier. A dosage of higher than 20 milligrams was found to be lethal.

But one significant result obtained from this experiment was the difference between the different groups in fluorine retained.

Group II animals—which had been given bone meal supplement—retained actually $\frac{3}{4}$ as much fluorine as the animals of group III. This would explain how with a higher level of phosphorus, the animals are less likely to reach toxic concentration of fluorine deposit in the bone.

Ameliorative measures.—The method of amelioration was studied along two lines, (1) preventive or prophylactic and (2) curative.

Preventive methods.—As fluorine in excess of one part per million in drinking water has been proved to be the prime factor in the incidence of the disease, the following attempts were done to get rid of this trouble.

Changing the water-supply.—Mention has already been made of the curative villages. Cattle dealers are in fact doing a good business by buying cattle at a nominal price from the affected village and removing them to these curative villages and keeping them there for some months. The animals recoup their condition and are then sold for a higher price. But this method is not within the easy reach of ryots who have either to remove the animals to the curative villages or obtain drinking waters from distant sources. The remedy is possible only where drinking water of low fluorine content is nearby and cannot therefore be of universal application.

Tapping the water source for different depths was another line thought of, but this method was bound to be a failure. We have already seen that the geological formations themselves are the sources of fluorine and even if one is lucky to strike a fluorine-free water source at a lower depth, it is likely to be contaminated near the surface, unless a protective pipe is led down from the very top. The success is doubtful and the cost will be prohibitive even for Government.

Removal of fluorine from the drinking water by chemical reactions was next studied. Based on work elsewhere, several reagents were tried as follows—boric acid, potash alum, tricalcium phosphate, superphosphate, alumina cream, calcium carbonate, freshly slaked lime, lime and superphosphate, lime and alum, were all tried, the cost of the treatment being also taken into consideration. Of the various reagents tried lime was found to be most effective and cheapest. The next set of experiments was to find out the most suitable dosage and the period of time the lime should be in contact with water. From the mass of data obtained it was found that a dosage of 500 parts per million was the optimum.

This result which was obtained from laboratory trials with artificially prepared water of known fluorine content was then confirmed by trials with natural waters in the locality; 14 samples of well water from Kurnool district were treated with lime and it was noted that the fluorine was reduced to negligible quantities, far below the dangerous limit of one part per million.

The action of lime (calcium oxide) on fluoride waters is due to the formation of calcium fluofride which is highly insoluble and hence settles down. Any excess of calcium oxide added forms first calcium hydroxide; this hydroxide due to the exposure to the carbon dioxide of the atmosphere, forms calcium carbonate which is also insoluble and which again settles down.

With effectiveness of calcium oxide established by laboratory trials, as a precipitating agent, rather spectacular attempt was then tried, by extending the treatment to a well itself. A step well at Gospad, which was mainly used for animals, was treated with lime on 16th December 1942 for removal of fluorine. The diameter of the well was 22 feet and depth of water 24 feet. Based on these measurements, 8¾ maunds of slaked lime obtained from Nandyal were added straight to the well. Six men were made to swim, dive and churn with poles, so as to ensure the complete mixing of the lime added. The lime got mixed up well and the water turned milky white, but the lime settled down completely in 36 hours. Samples of water for analysis, were drawn before the addition of lime and on three successive days after the addition and on the 18th day after the treatment.

The results showed that the fluorine content of the well water which was about four parts for million fell by about 40 per cent within three days; but this did not go below the threshold value of one part per million. Further on the 18th day the water came up to its original value of 4·75 parts per million. From this it was evident that treating the wells would only cause a temporary lowering of the fluorine content, which would soon be made up by fresh supplies from the well springs.

Curative method.—Absolute cure is not possible in advanced cases where bone eseostosis has set in. In the early stages of the disease previous workers have tried the following as methods of curing, (1) supply of vitamins, (2) a change in the dietary constituents, (3) supply of aluminium and (4) supply of calcium and magnesium.

Vitamins.—Previous work on rats, monkeys and human beings have shown that amongst the vitamins, vitamin C has a correlation with fluorine. Experiments with monkeys showed that Vitamin C caused lesser storage of fluorine and less pronounced bone affection. Thus vitamin C can partly ameliorate fluorine and this is probably one reason why cattle in the Kurnool district recover when taken to what are called curative villages, where in addition to the low content of fluorine in the waters, an abundance of green foliage which is a potential source of vitamin C, is available.

Change of diet.—Attempts have been made to ameliorate the disease by changing the dietary constituents, or supplementing certain end products of carbohydrate metabolism. This was based on certain experiments which showed that fluorine inhibits carbohydrate metabolism by preventing lactic acid formation. To get

over this, lactate, lactic acid and glycerol were introduced in the diet, but the results showed that such inclusions did not diminish the severity of the disease.

Aluminium.—Aluminium forms an insoluble compound with fluorine and investigators have found that an administration of 20 parts per million of aluminium lessens to a certain extent the storage of fluorine. The results, however, with experiments on rats were not always consistent, as aluminium also combines with phosphorus, forming an insoluble compound and this interferes with mineral metabolism. At best aluminium administration can only be a temporary relief but not a permanent ameliorative method.

Supply of calcium and magnesium.—Experiments by previous workers have shown that a low calcium in the diet of rats increased and a higher calcium decreased the toxicity of sodium fluoride. On the other hand the magnesium content of either the food or drinking water did not seem to have any effect on the incidence of fluorosis or its prevention.

Ryots' remedies.—Mention may be made at this stage of some practices prevalent in the locality to afford relief. As the animals go lame with fluorosis, the ryots blindly noting the localisation of pain in joints brand the animals as a counter irritant to cure the affected part. Again some herbs of known value in the cure of ordinary rheumatism are also tried, under the impression that the disease is a type of rheumatism. Of the herbs, three—*Cadaba indica, Clarodendron phlamoides* and *Pergularia extensa*—(known in Telugu as *Addamulinka, Takkalamu and Dustipatika* respectively) are in general use. But neither branding nor the use of these herbs has been found to be of any effect for curing the disease or even affording temporary relief.

Bone-meal administration.—It has already been mentioned that bone-meal had no ameliorative effect on experimentally induced fluorosis. It did not prevent altogether the appearance of the symptoms, although it did cause a lesser storage of fluorine. In the experiments, however, calves got an intoxicating dose of fluorine very much in excess of what is possible merely by drinking water-supply. It was therefore considered possible that bone meal administration could be tried as an ameliorative measure under the normally existing field conditions. During the field survey a cow was met with in Joladarsi village of Koilkuntla taluk where bone meal administration had ameliorated the condition. The Madras Veterinary Department had also attempted with some success a few preliminary trials on bone meal feeding. A systematic attempt was made to study this question. Four naturally affected bullocks from Dosapadu village were stationed at Agricultural Research Station, Nandyal which is itself a curative place with a fluorine content of less than one part per million in the drinking water. The animals were divided into two groups; one group receiving

the basic ration with change of water and the rest received in addition three ounces of bone meal per day. The basic ration was, 15 lb. cholam straw, five pounds green fodder, one pound each of groundnut cake and cotton seed and one ounce common salt. The animals were weighed periodically.

By a mere change of place from Gospad to Nandyal all the four animals started increasing in weight and even recovering from the disease. Within a period of 40 days the lameness also disappeared. The animals which were getting bone meal in addition put on weight much faster and recovered more quickly. At the end of ten weeks the non-bone meal group showed an average increase of 8·9 per cent on the original live weight while the bone meal group showed an increase of 16·38 per cent, a figure nearly double.

In conclusion, therefore, it may be stated that amelioration of chronic fluorine intoxication is possible by bone meal feeding and its good effect is enhanced by changing the animal to a water-supply in the curative areas. Where transfer of animals is not possible the drinking water must be treated with calcium, otherwise mere bone meal feeding will not be effective.

Studies on poultry nutrition.—In 1936–37 work was started to study the effect of feeding on the quality of egg and flesh in poultry. One group of birds received a diet containing fish meal while the other was fed with a diet containing groundnut cake protein. The eggs and flesh of birds of both groups were analysed later, not only for the total content of protein but for the differential make up. These preliminary experiments in fact showed that the egg and flesh of fish meal group contained more of the amide fraction. Further studies with a fresh batch of month old light sussex chickens did not however corroborate this finding. In the latter experiment, one batch of birds had fish meal and another groundnut cake as the main source of protein, the diets of both the groups being maintained at 11 per cent level. Birds from each group were slaughtered during the progress of the experiment and tissues of the wing and leg analysed for Haussman numbers. This analysis enables the proteins of the flesh to be partitioned off into several groups like, ammonia nitrogen, humin nitrogen, basic nitrogen and non-basic nitrogen.

The Haussman numbers revealed no differences in the protein make up of the flesh from the two groups of birds under experiment. The total nitrogen in all the birds was between 14 and 15 per cent of which seven to eight per cent was accounted for by the non-basic nitrogen. These results showed therefore very little difference in the distrubution of nitrogen in the two groups of birds. Considering that the protein of groundnut cake and fish meal are different in their make up, it is clear that feeding with different proteins does not alter the proteid composition of the flesh.

Wool production in sheep—Its quantity and quality.—Work elsewhere has fairly definitely established that cystine—a sulphur containing amino acid, has much to do with the quality of wool. Finer wool was found to be associated with a higher cystine content than coarser wool. The local breed of sheep at Coimbatore have a coarse wool, almost degenerating into hair. Breeding is the general method adopted to increase the yield of wool in sheep and to effect an improvement in its quality. With the knowledge that fineness of wool and higher cystine content go together, studies were started in the animal nutrition section at Coimbatore in 1931–32, to elucidate this problem.

The animals under trial were the Hosur black faced sheep obtained from the Deputy Director of Agriculture, Livestock. Preliminary experiments were started by feeding small quantities of sulphur. These experiments indicated that the animals reacted to sulphur feeding; the sheep that got sulphur gained 11;3 per cent in weight as against 6·3 per cent of those not receiving sulphur. There was also experimental evidence to prove the biological conversion of elemental sulphur into the sulphate form through the agency of the sulphur oxidising organism in the intestines. A portion of the sulphur fed was also retained as such without being oxidised in the liver.

The experiments were continued for three years, but apart from the increase in the weight of the animals no other improvement either in the yield of wool or its quality was noticed as a result of sulphur feeding. Some other valuable information on sulphur metabolism was obtained. A point of toxicological interest was that the sheep could tolerate 2·5 gms. of sulphur per day in the feed. It was also noticed that feeding of elemental sulphur caused a less retention of dietary nitrogen in the body. This depletion of nitrogen, although it did not produce any disease symptoms, was reflected in the altered composition of the tissue proteins, chiefly in the liver, thigh muscles, the brain and the kidneys. The conclusion finally drawn was that although it does not improve quantity or quality of wool, sulphur has a biological function in the body.

Nutritive value of crops as affected by manuring.—That manuring increases the yield of crop is wellknown. With the increase in yield there is also a change in the composition of the crop brought about by different manures. Particularly in the case of food crops and fodder this effect of manures on the quality is as important, if not more important than an increase in quantity. Several lines of investigation have been followed in the Chemistry section from 1924 on this aspect. Mention has already been made in the chapter on Soils of the permanent manurial plots at the Coimbatore Central Farm. These plots are manured with cattle manure and with other fertilizers and excepting for one or two years when cotton or sugarcane was grown, the main crops raised

on these plots were cereals. The existence of these plots thus afforded cereal material under differentially manured conditions.

It was noticed that seed obtained from the cattle-manured plot germinated better, put on more vigorous growth and yielded more and better grains than seed from the complete mineral-manured plots, i.e., plots receiving the inorganic fertilizers to supply nitrogen, phosphorus and potash. These observations indicated that there was something in the cattle manure which imparted a particular quality to the cereal improving its germinating and reproductive capacity.

It was felt that along with these vegetation tests which definitely showed the superiority of cattle manure seed in germination and growth, some nutrition tests also should be carried out. For this purpose the collaboration of Lieut.Col. R. McCarrison, I.M.S., Officer in-charge of the Deficiency Diseases Inquiry, Coonoor, was utilized. Samples of wheat grain from the no-manure plots, complete mineral manure plot and from the cattle manure plots were sent to Coonoor and nutrition experiments with these grains were conducted with pigeons and rats. The report indicated that wheat from the plots receiving cattle manure was 15 per cent more nutritious than wheat from plots receiving mineral mixture. lieut.-Col.McCarrison also made the observation that disease symptoms produced by no-manure and mineral manure grain disappeared with the administration of cattle manure grain.

Thus the results of the nutrition tests were identical with those of the vegetation tests and it was, therefore, possible to conclude that manuring alters the character of the seed. Since the cattle manure grain corrected the deficiency disease symptoms, it was reasonable to conclude that the observed superiority of the grain was due to the vitamin content. As a corollary it followed that the organic manures supplied to the plant some stimulating constituents termed Auximones, which are similar to vitamins for animals.

If the seed obtained from an organic manured plot is superior to that from a mineral manured crop, it should follow that in the growth in the plant itself there must be a difference in the course of metabolism due to the different manures. The seed is only the final product of metabolism and a study of the changes during crop growth would throw more light on the differential effect of the manures.

The next line of attack of the problem consisted, therefore, of chemical studies of the proteins of herbage and seeds of crops receiving differential manure treatment. The work was taken up during the year 1937–40 under a scheme sanctioned by the Indian Council of Agricultural Research. The herbage studied were rice, maize, ragi and lucerne. Rice was grown under sullage effluent water from the activated sludge plant of Central Farm, Coimbatore

and under channel water. Lucerne was grown under no manure and cattle manure conditions. Maize had four manurial conditions—no-manure, cattle manure, mineral manure and sodium nitrate and creatinine. Periodical analysis of these herbage under different manurial treatments were carried out to study the intermediary phases of nitrogen metabolism. The nitrogen estimated was partitioned off into several fractions, as ammonacal, nitric, amido, humin, monoamino and diamino.

The results indicated that soil treatment by the application of the manure had a profound effect on the quality of the crop as measured by chemical analysis. The probable reason for the differences in nutritive value of crops is perhaps that the proteins synthesised were of different types as a result of manuring with organic and inorganic manures.

Generally application of heavy doses of nitrogenous manures like ammonium sulphate or farmyard manure brought about an increased up-take and increased metabolism of nitrogen; but in the case of inorganic fertilizers, the carbohydrate metabolism was reduced. As a consequence, in the plots treated with inorganic manures, the total protein nitrogen is low compared to the total nitrogen, since most of the nitrogen is accounted for as nitric and ammoniacal form. On the other hand, althuough the total nitrogen in the organic-manured plot was the same as that from the mineral manure plots, the proteid nitrogen is more and nitric nitrogen less. It would, therefore, appear that the imbalance in nitrogen and in carbohydrate metabolism is responsible for this differential distribution of nitrogen in the proteid and non-proteid forms. This probably is the reason for the loss in quality of the crop from the inorganic manures.

Miscellaneous studies on nutrition.—In this section are reported a number of miscellaneous items of investigation which cropped up during the pursuit of the main problems on animal nutrition.

Use of small animals for feeding experiments.—The technique of carrying out experiments on animal nutrition is beset with many practical difficulties; chief amongst these are the size and number of animals that have to be put under experiment. A simple digestibility experiment, for example, on working bullocks will require at least four animals to be studied and the cost of this apart from the cost of ration, attendants, etc., very often is not proportionate to the results achieved. In many cases what is wanted is a preliminary information which, if sufficiently encouraging, can be taken up for elaborate investigation.

To get over the disadvantage of large numbers and repetitions and to reduce the cost of equipment, small animals were chosen for the preliminary experiments. Animals so chosen for these purposes were rabits, guinea pigs, and white rats. These could be kept under

controlled conditions more easily than large animals which require specially constructed stalls. Wherever necessary, these animals were used for preliminary trials like nutritive value of different grasses, supplementing bonemal to the ration, fixing a basal diet and similar problems, on the results of which subsequent experiments on large animals could be modelled.

Biological value of proteids.—One set of experiments for which these small animals were found to be very handy and suitable was that on the determination of biological value of proteids. Proteids are nitrogenous structures built with amino acid bricks and it is a well known fact that the quality of a proteid depends on its amino acid make up. For example milk and egg proteids have a higher biological value. Similarly proteids of animal origin have a higher biological value than plant origin. Amongst plant proteids themselves, there is difference between one species and another, between one variety and other and between varieties grown under different conditions. In 1935–36, experiments with ragi indicated that white ragi had a higher biological value than the brown variety. On the other hand, ragi grown on differently manured plots showed no differences, indicating that the varietal factor was responsible. Similarly, there was a difference between redgram varieties grown on hills and plains near Coimbatore, the type on the plains showing a higher biological value. The experiment was also done with rice, 15 different varieties from Coimbatore, Aduthurai and elsewhere being studied. The general conclusion was that short-duration varieties had a higher biological value than those of longer duration. Starchy variety again had a higher value than glutinous types. Another set of interesting experiments which might also have a value in human nutrition was with parboiled rice, raw polished rice and with raw unpolished rice. The result indicated that polishing lowered the biological value.

Utilization of molasses.—Molasses, a by-product obtained from sugar factories was tried in some feeding trials and the result showed that the molasses could well supply a portion of the carbohydrate constituent of the diet. Based on the experiments done in 1936–37, composite cakes were prepared from molasses by mixing with concentrates and mineral mixture to give hard bricks of definite composition. The cakes were designed to be of suitable size and weight to supply 100 grams of digestible proteid—the requirement for maintenance. These cakes had a good keeping quality and as they disintegrate freely in water what was wanted was merely to soak them in water and give them as feed to the animal. Extra proteid required could always be supplied by increasing the number of bricks.

In addition to the experiments with the small animals on the biological value of different feeds, the constitution of proteid by an analysis and estimation of amino acids in the laboratory was also studied. Amongst the amino acids, tryptophane is known to be essential. According to work done elsewhere, this amino acid is

not found in the prolamine, a characteristic cereal proteid found in the sorghum plant. Laboratory studies at Coimbatore with *Peria-manjal cholam*, a local variety, however, showed that prolamine obtained from this cholam variety contained tryptophane. This was a very interesting finding because in other countries sorghum fodder is not commonly used by stock-owners, while in many of the districts of Madras State, sorghum straw is the main roughage for cattle. The results of the laboratory investigation are therefore valuable since they indicate that our cattle which are fed on sorghum straw are not starved for their tryptophane supply.

Silage investigation.—During the years 1929–39, the bio-chemical changes occurring when green sorghum fodder was converted to silage were studied. It was revealed that in the first three months as much as 30 per cent of the original matter is lost but there was no further loss even after eight months. During the first three months again there was a rise in the acid content, the amino acids produced by fermentation reaching a maximum value during that period. There was a total loss of 16 per cent proteid in the original content and it was indicated that a period of 3 months is more than enough to complete a silage process. Without undue disturbance and by preventing entry of air into the material it was found that silage could be preserved without loss of nutritive value for nearly one year.

Protein reduction and carbohydrate increase in diet.—According to accepted principles of animal nutrition, depending upon the age and condition of the animal and the work it produces, a certain amount of carbohydrate, fat and proteid have to be included in the diet. While carbohydrate and fat are only energy suppliers, protein supplies mainly materials for tissue building, although in the process it can also supply energy. From this it would appear that an animal on a submaintenance level of protein might be enabled to do work if in place of the proteid it is supplied carbohydrates in excess. An actual experiment was done in 1940–41 to test the possibility. An animal with only 75 grams instead of 100 grams digestible proteid required for maintenance was given 1,200 grams of sucrose during periods of work, but the results showed that inspite of feeding large quantities of easily available carbohydrates, there was increased nitrogen excretion, showing that there was tissue break down. This was confirmed by excretion of sulphur and phosphorus. The investigation therefore showed that there is no advantage gained by increasing carbohydrate and reducing proteid in the diet.

Improving palatability of coarse straws.—In Coimbatore district bajra straw is not fed to cattle as it was not relished by them. Feeding trials were therefore started in 1946–47 to investigate the possibility of feeding it along with other straw. The experimental animals were given the same feed in the beginning as the controls except that bajra straw was slowly substituted in instalments in

place of sorghum straw, starting with 25 per cent in the first week and ending with 100 per cent bajra straw in the sixth week. Live weights periodically recorded showed no difference between the experimental animals and controls. It was shown that bajra straw could be utilized as fodder without deleterious effects.

Another line of investigation was to improve the palatability by previous fermentation of the straw. Treatment with alkali has been found to improve the nutritive values of straw by raising their starch equivalent and causing a greater assimilation of carbohydrates and minerals. Alkaline treatment is, however, costly and an attempt was made to see if this could be replaced by composting. Bajra straw, molasses and ammonium sulphate respectively as starters was composted in cement concrete tubs for two months. At the end of the period, the fermented straw had the colour of silage, though the smell of acetic acid was prominent in the molasses compost and uric acid in the ammonium sulphate compost. Four animals under experiment which received 70-75 lb. of this as wet products per day each were found to be healthy in condition. Laboratory analysis however indicated that there was no improvement in the nutritive value of compost over that of the original straw. Economically, therefore, composting is not feasible and the better method will be to gradually accustom the animals to bajra straw instead.

Treacle as diet for dairy animals.—Coimbatore is an important sugarcane growing and jaggery producing centre and during jaggery boiling season, there is a prevalent practice of including in the ration of dairy cattle the treacle obtained from the pans. It is claimed that this increases the yield of milk. Actual experiments, however, with treacle used as part of ration for dairy cattle did not show any improvement either in the yield or in the quality of milk.

Improving breeding bulls by a change of diet.—A rather interesting instance in which the Government Agricultural Chemist had to do an experiment for increasing the potency in breeding bulls may find mention here. In 1929, the Deputy Director of Agriculture, Livestock, brought to the notice of the Chemist instances where breeding bulls refused to serve cows. Two such buffalo bulls and one Kangayam bull were actually sent from Hosur to Coimbatore for an experimental study. As a first step, the concentrates which the animals were receiving were cut by half and they were given work regularly. In addition, they were given daily 1½ lb. of sprouted sorghum seed and one lb. wheat bran. In the course of six months, it was noticed that the animals became quite effective for service and looked improved in condition. The idea behind the supply of sprouted sorghum and wheat bran was to assure sufficient germ to provide the fertility factor.

Human nutrition.—Malt is the term given to the product obtained from cereal grains by germinating them under controlled conditions of moisture and temperature. During the germination of a seed, certain biochemical changes are brought about by the enzymes present in the seed material which become active under the conditions favourable for germination. As a result of these chemical changes the complex food materials in the endosperm like protein and carbohydrate get broken down into simpler compounds like polypeptides and soluble sugars. These simpler compounds are easier to digest and assimilate so that it is easy to see that infants, invalids and persons with weak stomachs could find it an advantage to take properly prepared malted grain in place of the whole grain. It is this principle that is utilised even in our own country in the indigenous preparation of redgram dhall for the market. Redgram (*Cajanus indicus*) smeared with moist red earth for one or two days and then cleaned has always a higher value in the market than the unprepared stuff. There are certain places in the Madras State like Tirupathur in Salem district where with empirical methods this process of preparation of redgram dhall has been developed almost to perfection. Wrestlers, boxers, gymnasts and atheletes generally take as their first meal in the morning a handful of Bengalgram soaked over night and it is considered that this is essential to keep them in fit condition. Sprouted pulses made tasty with salt and lime juice form one of the items of the menu for many religious feasts. All these go to show that the principle of malting has been utilized although its rationable was not correctly understood.

Malting has been perfected to a very high state of efficiency in other countries. Barley is the cereal mainly used and every one is today familiar with the patent infant and invalid foods like Horlicks, Benger, Mellins and so on. All these have as their basis Barley malt to which has been added milk powder, sugars, glycerophosphates and vitamins to make them complete and perfect foods for the convalescing patient.

Barley is not an important cereal of Madras. As a matter of fact excepting on a few acres in Nilgiris it is not grown anywhere else. But the possibility of utilising the other cereals especially sorghum and ragi for preparation of malt has been engaging the attention of the Agricultural Chemist from as early as 1916. As a result of several attempts in the laboratory several products obtained from cholam malt similar to the imported foods were manufactured in the laboratory. These of course were not ideal to be compared with Horlicks but these early laboratory attempts showed the possibility of utilising Madras cereals for Malt manufacture. As a matter of fact so good was the impression created by the exhibition of the labortary samples in the Madras Park Fair Exhibition of 1917 that one of the few gold medals given that year was awarded to the Agricultural Chemist for the samples of malted foods exhibited.

While the laboratory investigations thus showed the possibilities of using Madras cereals for malt production, in 1926, a collaborative study was taken up with the Industries Department on the prospect of developing it as a large scale industry. The earlier investigations were continued on a semi-industrial scale at Coimbatore and it was demonstrated that malt of good quality could be manufactured on a large scale.

Private enterprise was not, however, forthcoming to take advantage of the results of research and for several years the Department had to be content with propaganda on the method of malt manufacture. If the production could not be taken up as a large scale concern at least it could be developed as a cottage industry and it was on this aspect that work was done for the next few years. A fool-proof method with easy-to-follow charts and flow sheets were developed and whenever possible through leaflets and through demonstrations in public exhibitions and in schools, attempts were made to popularise malt production in the home.

In the meanwhile further scientific work to develop and improve the technique was being continued and a scheme financed by the Indian Council of Agricultural Research in 1936–38 made several investigations possible. The several stages in the processes of malting were studied in detail, like steeping, couching, polishing, kilning and powdering. It was indicated by these studies that the best results were obtained by steeping for a period of 24 hours, couching for over a week and kilning at a fairly low temperature so that the diastase is not destroyed. The Research Engineer whose help was also taken in these investigations was also able to design a polishing machine suitable for the removal of husk.

Whereas previously it has been found that it was not possible to preserve cholam malt for more than three months without deterioration, it was found during these latter investigations that malt can be packed in vaccum tins without loss of aroma and without deterioration for nearly three months.

With cholam malt as basis, successful attempts in the laboratory were further made to prepare foods of the type of Ovaltine, Malt extract and results showed that in cupric reducing power cholam malt was as good as Bengers. It was also established that malt could be used in the preparation of biscuits, cakes and bread, increasing the taste and digestibility of these products. Experiments with other cereals were also successful and it was shown that blending of malt foods from two or more chosen cereals could be utilised to reduce the fat content and deterioration of the product.

With the possibility of malt production from sorghums being thus established, experiments were also done at the Animal Nutrition Section, by feeding malt to rats. Malt was also supplied to hospitals and nursing homes to ascertain medical opinion. The

results were all encouraging, so that in 1939, when at the time of the War, there was demand for malted foods from the front, the Madras Government started a Malt factory at Coimbatore for the manufacture not only of malt food, but of malt extract enriched and vitaminised with shark liver oil.

A detailed account of this factory will be found in the Chapter on Agro-Industries.

Analytical data on vegetables and fruits.—Along with other analytical studies, the examination of the composition of several Indian vegetables has been a regular routine feature of work in the laboratory of the Government Agricultural Chemist for several years. Bazaar samples which vary much in condition are not used for these analysis. Vegetables grown on the Central Farm, Coimbatore, supplied the material and since they are grown on the same soil and under identical conditions, the figures of analysis give a correct estimate of their relative food value.

A statement of the analytical data so obtained is furnished at the end of this chapter.

Among the beans, Goa beans are richer in protein and lime than cluster or French beans. Of the gourds, bitter gourd is richer in phosphoric acid and proteins than snake or ribbed gourd. All the gourds are poor in lime.

Tomato ripe is about 50 per cent richer than the raw in protein, phosphoric acid and lime, while the lime content is double that of raw. Ladies finger is as good as bitter gourd in proteins and phosphoric acid but contains three times as much lime.

ANALYSIS OF VEGETABLES.

Results of Analysis of Eleven sample of Vegetables from the Central Farm, Coimbatore.
(Edible portions only.)

Percentages—Calculated on green matter.

Heads of analysis.	*Cluster Beans.*	*French Beans.*	*Ladies Finger.*	*Snake Gourd.*	*Ribbed Gourd.*	*Bitter Gourd.*	*Amaranthus (Stem.)*	*Amaranthus (Leaf.)*	*Tomato (Raw.)*	*Tomato (Ripe.)*	*Goa Beans.*
Moisture	85·43	89·89	91·75	95·08	95·52	91·39	94·50	87·58	95·48	93·61	93·01
Ash	1·27	0·92	0·87	0·43	0·34	0·83	1·56	2·86	0·64	1·08	0·64
Proteins	3·12	2·52	1·90	0·92	0·78	2·00	0·91	3·22	0·96	1·56	2·08
Albuminoids	1·34	1·46	0·79	0·49	0·59	1·53	0·44	2·52	0·71	1·18	1·39
Ether Extractives ..	0·11	0·12	0·11	0·04	0·05	0·32	0·05	0·12	0·29	0·41	0·08
Fibre	2·17	1·81	1·19	0·65	0·43	1·48	1·02	1·14	0·57	0·95	1·35
Carbohydrates ..	7·90	4·74	4·18	2·88	2·88	3·98	1·96	5·08	2·06	2·39	2·84
Insoluble mineral matter.	0·01	0·02	0·02	0·02	0·02	0·02	0·03	0·13	0·01	0·01	0·02
Phosphoric acid ..	0·14	0·14	0·14	0·05	0·06	0·11	0·04	0·13	0·06	0·09	0·09
Potash	0·45	0·41	0·31	0·14	0·13	0·39	0·59	0·55	0·30	0·48	0·22
Lime	0·16	0·06	0·09	0·04	0·02	0·03	0·15	0·67	0·01	0·02	0·12

CHAPTER 25.

AGRO INDUSTRIES.

Malt and malt products—The Government Malt Factory, Coimbatore—Buildings, equipment, production—Malt food, malt extract—Analytical standards—Training centre—Cost of production.

Ergot of rye—Preliminary experiments—Rye cultivation and fungus inoculation at Nanjanad—Schemes sanctioned—Suitable localities in Madras—Cost of production.

Food yeast manufacture—Early experiments in the mycology section—The laboratory plant—Manufacturing process—Chemical composition of yeast sample—Pilot plant—Future possibilities.

Annato dye—Early trials and final method evolved for manufacture of dye from Annato seeds.

Starch and starch products from tapioca and arrowroot—Utilization of groundnut husk—Activated carbon—Preparation from groundnut and paddy husk—Vegetable oils from inedible oil seeds—Tobacco seed oil—Press mud and its utilization—Pectin from tamarind seed—manufacture of nicotine insecticides.

The main aim of the Madras Agricultural Department has been to increase yield of crops by the adoption of improved varieties, cultural methods, manuring practices and proper soil management. At the same time, every opportunity has been taken advantage of to explore the possibilities of utlization of agricultural produce, both raw materials and bye-products. Items relating to such investigations have been mentioned in several chapters wherever there was a relevancy for reference to them. In this chapter, " Agro. industries ", will be found those investigations which have gone beyond the laboratory stage and which are now being run on an industrial basis, as definite activities of the department.

Malt and malt products—Government Malt Factory, Coimbatore. Malted foods and Malt Extracts are important constituents in modern diet and form a part of almost all invalid and baby foods. The Malt industry may, therefore, be classified as one of the vital industries of great national importance as it caters to the needs of children and sick people.

Malt is utilised in the manufacture of several patent malted foods and pharmaceutical preparations. It is used in the manufacture of malted milk, beverages, caramels and confectionery. Extract of malt is used as diastatic agent in textile industry. Malted grain after extraction is a useful concentrated cattle feed. The Malt Industry in India is still in its infancy. The Government Malt Factory at Coimbatore is the only one of its kind in India, where malt extract is manufactured on a commercial scale. A few pharmaceutical concerns, however, produce small quantities of Malt Extract for their own use. The bulk of our requirements of malted and farinaceous foods is imported from other countries.

The quantity and value of pre-war and war-year imports are given below :—

Imports of Malted Foods and Farinaceous Foods (including Infant Foods).

Year.	1937-38.	1938-39.	1939-40.	1940-41.	1941-42.	1942-43.	1943-44.*
Quantity in pounds.	375,339	428,275	368,275	371,132	437,312	24,050	9,885
Value in rupees	74,11,330	76,78,141	8,53,283	84,73,300	94,74,439	17,02,039	11,58,056

* Fall in imports due to war.

The magnitude of the imports proves the popularity of these foods and the necessity for improving the infant and invalid food industries in our country.

When any cereal grain is subjected under controlled conditions to the various processes of soaking, germination and drying the resultant product is known as " Malt ". During the process of germination the food material of the seed is converted into simpler substances for the nutrition of the seedling. The conversion products being soluble in water afford proper nutrition to the young seedling and are suitable as food for babies and sick people with weak digestive powers.

Background and brief history.—Malt is generally prepared from barley, which is not available to any large extent in South India. Investigations were, therefore, undertaken by the Government Agricultural Chemist, Coimbatore, to explore the possibilities of utilizing cereals available in the State and to develop the malt industry in order that at least a portion of the requirements of malted foods may be met from local manufacture. As a result of these investigations it was possible to undertake production of malt food and malt extract from sorghum on a large scale at the Government Malt Factory, Coimbatore. The investigations were commenced during the first World War of 1914–18. The scientific and practical results of the investigation were ready by 1917 and cholam malt products were for the first time exhibited at the Great Madras Exhibition in 1917.

Subsequently in 1924, the interest in malt products was revived when Government ordered that experimental work should be carried out for manufacture of malt food and malt extract on a fairly large scale and provided special plant and staff. The Government reviewed the work carried out and was convinced that it was possible to produce malt food from sorghum, but decided that it should be left to private enterprise to take up the manufacture on a commercial scale. The results obtained showed the need for further detailed study of the chemistry of malting of sorghum and a scheme was sanctioned by the Indian Council of Agricultural Research in 1935 for three years for this purpose. During the tenure of the scheme an intensive study of the conditions required for the proper malting of cholam was made.

Samples of malt food prepared were subjected to clinical tests in several Government hospitals of the State. The reports received from the hospitals indicated that it was suitable for infants, invalids and convalescents and that it was specially indicated in gastro-intestinal disorders.

Government Malt Factory.—In 1941 at the commencement of World War II, interest was again stimulated in the manufacture of malt products owing to the total lack of imports of malt foods from abroad, and the need for making substitute foods in this country from indigenous material. At the instance of the Supply Department of the Government of India, the Government of Madras undertook to put up a plant for the manufacture of malt food and malt extract with shark liver oil, and assigned the work to the Agriculture Department which had previous experience in the methods of malt manufacture. The Government Malt Factory at Coimbatore started production of malt food and malt extract in 1942 on a pilot plant scale. This having proved successful, further modifications were introduced and units required for large-scale manufacture were designed and built out of locally available material. Owing to war conditions, great difficulties were experienced in getting together the necessary equipment and almost all the units had to be designed and fabricated within the State. Large-scale production started in November, 1943 though the entire plant could be completed only at the beginning of the year 1945.

Buildings and equipment.—The buildings were put up at a cost of Rs. 65,000 and the plant and machinery at a cost of Rs. 1,60,000. The buildings consist essentially of two large sheds for the production of malt food and malt extract, store rooms, machine room, boiler shed, one stirring room, one set of office rooms, fumigation chamber, silo, drying platform, grain godown, and five couching rooms. The machinery and equipment consist of air conditioning units for couching rooms for working at 65°–67°F., steeping vats, polishers, roasters, grinders, sieves, copacking equipment, steam jacketed 50 gallons pans, centrifuges, vacuum filters, vacuum stills and auxilary equipment like vacuum pumps, boilers, stirrers, one set of four units of pilot plant, storage racks and all essential tools.

Malt food.—The Malt Factory was in operation at the beginning for the manufaure of malt food only and the manufacture ning for the manufacture of malt food only and the manufacture was a straight malt food without the admixture with milk, sugar or flavouring substances and was meant to replace the infant and invalid foods like " Horlicks," etc., when used with added fresh milk. The keeping quality of this product in large-scale manufacture was, however, very poor and the off-take by the public also was disappointing with the result that its manufacture had to be stopped from August 1945. In order to improve the keeping quality of the product and keep it free from insect attack a series of experiments on the method of packing were conducted. Investigations

showed that pre-treatment with heat at 60°C. for 10 minutes, prior to packing in CO_2 gas, will secure destruction of all stages of insect life. Another serious defect was the onset of rancidity on storing even for short periods. The raw material sorghum, unlike barley, contains a high percentage of fat which probably turns rancid during storage.

The process employed in the manufacture of malt food is briefly as follows :—

Sorghum seeds of high germination capacity (above 85 per cent) are cleaned, steeped in water for 24 hours and allowed to germinate in the couching rooms for four to five days on wire gauze trays. During the process, the enzyme breaks down the starch into easily assimilable sugars. After germination, the malted grains are sun-dried to green malt which is polished, roasted, ground and sieved. The fine powder is called " Malt Food ".

Malt extract.—With the unavoidable stoppage of malt food production, the machinery and labour were utilized for the production of malt extract, which was in demand by the Medical Directorate. Malt Extract prepared from sorghum is a standard article and has been found to be an excellent one. The malt extract is fortified with high potency shark liver oil to give a guaranteed vitamin A content of 200 I.U. and vitamin.

Manufacture of malt extract requires expensive machinery and careful supervision. Green malt mixed with an equal quantity of roast malt is mashed with water at 60°C. for four hours and the thin extract centrifuged and passed through vacuum filters. The clear filtrate is concentrated into highly viscous malt extract (specific gravity 1·43). This extract is blended with shark liver oil.

The maximum amount of diastatic activity develops in sorghum when the grains are germinated for four days in a 1½ inches thick layer in couching trays at 65°–67°F. A critical study of the various processes in the manufacture of malt extract revealed a number of important points to be observed during manufacture. It was found that the extract drawn below the standard specific gravity and the extract obtained with high mashing temperature have very low keeping quality and have a marked tendency to develop mould growth during storage.

It was found that due to certain difficulties a filter press could not be used to replace centrifuges and vacuum filters for clarifying the mash liquid.

The final concentration of the dilute extract must be done below 70°C. to avoid caramelisation and consequent undesirable flavour.

A number of trials were conducted from time to time, (i) to reduce the cost of production either by increasing the yield of extract or by economising in the use of raw materials like activated

carbon, etc., (ii) to improve the quality of the extract by modifications in the mashing process, and (iii) to find profitable outlets for the by-products. The results are as follows. Maintaining a uniform temperature of 60°C. while mashing gives an extract of high quality, rich in sugars. (2) Sorghum malt extract manufactured at the Factory contains about 3·0 per cent protein and 125 units of vitamin B1 per 100 grams. It contains 70 per cent sugars as maltose. (3) Preliminary experiments have shown that malt extract cannot be dried satisfactorily on hot plates or in vacuum ovens. A spray-drier with atomiser arrangements would be necessary. (4) Increasing the malt-water ratio of mash or prolonging the mashing time beyond the normal four hours does not increase the yield. (5) A second extraction of malt refuse with addition of fresh green malt as source of diastase is not economical. (6) Fine grinding of mash mixture does not increase the yield of extract; on the other hand, it often leads to difficulties in filtration. (7) Couching at ordinary temperature, especially during the winter months, is satisfactory for malt extract production. (8) Malt refuse is rich in carbohydrates and crude proteins and is, therefore, a valuable stock feed. Fairly good quality starch can be prepared from it by preliminary fermentation, alkaline treatment and lixiviation. (9) Coarse gravel in conjunction with four lb. of activated carbon instead of the usual ten lb. of activated carbon per charge can be used for filtering the mash liquid, without adversely affecting the quality or yield of extract. (10) Barley malt can be used as a source of external diastase in the manufacture of malt extract from sorghum.

Sales and distribution of malt extract.—During 1944–45, and 1945–46, large quantities of malt extract were taken by the Medical Directorate for the Defence Department. By the end of 1945, the contract with the Medical Directorate was cancelled due to the cessation of hostilities and for the time being the only outlet for sales was the then agents who were just able to sell only 600 lb. per annum, with consequent accumulation of large stocks. With the Surgeon-General's recommendation that the malt extract manufactured at the Government Malt Factory is of standard quality and could be used in all hospitals, there was a regular demand from the hospitals. The entire stock of the factory was sold through the various Agricultural depots in the State. The indents from hospitals have since been on the increase and at present almost all the Government hospitals and medical institutions under the municipalities and district boards take their regular supplies from this factory.

The working of the Malt Factory till 1945 having shown a loss, the economic position of the Factory was reviewed in 1946. The Government decided to run the Factory for production of malt extract only with a target of 27,500 lb. per annum. All the non-essential items of buildings and equipments were, therefore, transferred to other officers of the department to reduce the depreciation charges and interest on capital outlay. Production,

which was at a standstill for want of sorghum in 1948, was restarted and regular production has been maintained. Steps were taken to widely advertise the product by distribution of samples, by cinema slides and by participating in important exhibitions. Samples were also sent to other State Governments for trials in the State Hospitals to popularise the product.

The Government Malt Factory was constructed and equipped during a period beset with formidable difficulties. The main difficulty was the soaring price of all materials used in its construction. This necessitated a high capital outlay and consequently the interest and depreciation charges act as a heavy charge on the profit margin. Added to this, the cost of raw materials, i.e., sorghum grain, fuel, shark liver oil and labour charges rose very sharply due to inflated conditions. Due to these, the Factory has not been able to run as a self-supporting concern. The demand position at the present moment, however, is very encouraging and during 1949–50 the hospitals alone have taken a quantity of nearly 20,800 lb. of Malt Extract. It is, therefore, hoped that with a growing demand and with increased production the losses will be wiped out and the Factory run on a profitable basis.

Malt Factory as a training centre.—The Government Malt Factory, being unique of its kind in the country, has attracted the attention of not only several private concerns but also of the Ministry of Industries and Supplies of the Government of India. The Food Industries Planning Panel strongly recommended that this institution should be converted into a training centre and a place for conduct of further research. Students are deputed from various places in India to this Factory to undergo training in malt manufacture.

Average analysis of malt extract.

(After A.E. Leach—Food Inspection and Analysis.)

Specific gravity	1·39—1·50
Albuminoids per cent	3·12—4·90
Maltose per cent	61·3—65·4

Standards for sorghum malt extract with shark liver oil.

Specific gravity	1·40—1 45.
Refractive index at 28°C. ..	1·4950—1·5000.
Total solids	80—82 per cent.
Total Sugars as maltose ..	Above 60 percent. (generally 65—75 per cent).
Acidity as acetic acid	0·6 to 0·8 per cent.
Nitrogen equivalent	2·8 to 3·2 per cent.
Vitamin A content	200 International units of vitamin A per gram.
Vitamin B_1	100–125 International units per 100 grams approximately.

REMARKS.—Thick, viscous, amber coloured liquid, having sweet taste and characteristic malt flavour and miscible with water in all proportions.

Pharmacopoeia Standards.

Particulars.	*B.P.* 1932.	*U.S.P. XII.*	*Sorghum malt extract.*
1 Miscibility ..	Miscible with water in all proportions forming a transluscent solution.	Soluble in cold water, but more readily soluble in warm water. Aqueous solution is clear and deposits a voluminous flocculent precipitate upon standing.	Miscible with water in all proportions, giving a clear solution.
2 Specific gravity ..	1·40—1·42 (15·5°C.)	1·350—1·430 at 25°C.	1·40—1·45 at 15·5°C.
3 Refractive index.	1·4892—1·4976 at 20°C.	..	1·4950—1·5000 at 28°C.
4 Arsenic limit ..	1·4 parts per million.	....	....
5 Protein content ..	Not less than 4·5 per cent.	....	1·8—3·2 per cent.
6 Diastatic activity.	....	Converts not less than five times its weight of starch into soluble sugars.	....
7 Total solids ..	....	....	80—82 per cent.
8 Sugars as maltose.	....	....	65—75 per cent.
9 Acidity as acetic acid.	....	....	0·6—0·8 per cent.
10 Vitamin B_1 ..	....	....	About 100 International units per 100 grams.

NOTE.—Commercially, malt extracts are assayed for their diastatic power (Lintner value), but since diastase is inactive *per os*, no such assay is required by the B.P.

Cost of production of malt extract and malt food (1945).

Particulars. (1)	*Malt extract.* (2) RS.	A.	P.	*Malt Food.* (3) RS.	A.	P.	*Remarks.* (4)
1 Raw materials (cholam, fuel, oil, power, etc.).	1	9	1	0	12	9	
2 Labour	0	4	11	0	5	7	
3 Establishment	0	1	11	0	2	2	
4 Depreciation, interest	0	15	5	0	8	1	
5 Office expenses (correspondence, postage, etc.).	0	0	6	0	0	6	
6 Bottles	0	9	6	0	8	0	
7 Other packing materials like labels, pamphlets, etc.	0	0	4	0	0	6	

Cost of production of malt extract and malt food (1945)—cont.

Particulars. (1)	*Malt extract.* (2) RS. A. P.	*Malt Food.* (3) RS. A. P.	*Remarks.* (4)
8 Packing in cases	0 2 2	0 2 2	
9 Railway freight within the Madras State.	0 1 5	0 1 9	
Cost per lb. f.o.r. any destination in Madras State.	3 13 3	2 9 6	
10 *Deduct* cost of coarse malt transferred for extract production.	..	0 10 9	
11 *Add* profit at 7½ per cent	0 4 7	0 2 4	
Cost per lb. f.o.r. any destination in Madras State including profit.	4 1 10	2 1 1	
12 *Add* commission to sole agents at			
(i) 10 per cent for malt extract ..	0 6 7	..	
and			
(ii) 15 per cent for malt food ..	..	0 5 0	
Total ..	4 8 5	2 6 1	

NOTE.—(1) The above data is based on an average monthly production of about 2,000 lb. of malt extract and 800 lb. only of malt food.

(2) Raw materials include cholam, coarse malt, firewood, charcoal, activated carbon, shark liver oil, essence, water and electricity supply. Cholam, firewood and shark liver oil are the costliest items in the series.

(3) The depreciation and interest charges are unduly high since production is not at its optimum.

(4) The cost of production is worked out on the basis of approximately half the normal working capacity of the plant. The cost of production is, therefore, high.

(5) Under normal working conditions, charges due to labour, depreciation and interest, fuel, etc., can be reduced considerably and the cost of malt extract with shark liver oil reduced by about 12 annas per lb. and that of malt food by about 6 annas per lb.

(6) The sale prices fixed are Rs. 4 for one lb. bottle of malt extract with shark liver oil and Rs. 2–4–0 for one lb. bottle of malt food. These are reasonable comparatively for the times which are abnormal.

(7) There is scope for a greater reduction in the prices in normal times.

Composition of Cholam Malt Food.

The results of a typical analysis of malt food (80 mesh) are as follows :—

Moisture	4·60 per cent.
Acid value	18·3 m. gm. KOH per gram of ether extract.
Ether extract	3·25 per cent.
Crude fibre	1·23 ,,
Cold water extract	12·8 ,,

NOTE.—The cold water extract is often as high as 17·0 per cent. The ash content is about 2·0 per cent.

Analysis of malt refuse.

Moisture	1·21	per cent.
Ash	1·28	„
Crude protein	11·93	„
Ether extract	3·23	„
Crude fibre	2·52	„
Carbohydrates (by difference) ..	69·03	„
Total ..	100·00	per cent.
Insolubles	0·092	
Lime (Cao)	0·142	
Phosphoric acid (P_2O_5)	0·602	
Acid value	28·92	Mg. KOH per gram of ether extract.

The malt refuse compares favourably with any cereal flour and may be a partial substitute for the usual concentrates. It is an excellent feed for milch cows.

ERGOT OF RYE.

Ergot of rye is an important drug included in British and other Pharmacopœia and used in the treatment of hæmorrhages especially *post partum* hæmorrhage and certain nervous disorders like migraine and shell shock. Raw ergot is a hard, dark, elongated sclerotium of the fungus *Claviceps purpurea* (Fr) Tul. about an inch or more in length and one sixth to one fourth inch in thickness. This fungus infects the ears of rye and a number of grasses replacing some of the grains in the ears by the sclerotia. Longitudinal cracks develop as the sclerotia reach maturity. When the crop nears harvest and during harvesting operations many of these sclerotia are shed and they remain dormant in the ground through the winter months.

In the spring, the sclerotia begin to germinate and produce reddish pin-shaped structures in which perithecia are developed. The ascospores from these are forcibly ejected into the atmosphere and carried upwards by currents of air. Some of these reach the open flowers of the new rye crop or other host plants and start infection. Ten to fifteen days later 'honey dew' formation becomes evident. Pearly, viscous drops of fluid extrude out of the infected flowers. These drops are slighly sweet to taste and contain numerous conidia of the fungus in suspension. Insects, mostly flies, are attracted to these and they help in the spread of infection. In four to six weeks, sclerotia are formed and can be readily recognized.

Rye is an important grain crop in many of the European countries where natural infection by ergot is common. Before the World War No. 1, Russia, Spain, Portugal and Germany were the chief countries from which ergot was obtainable. An acute

shortage was felt during and after the two World Wars, which stimulated artificial infection and production of ergot in various countries.

In India preliminary experiments at artificial infection were made in 1942. Fresh cultures of the fungus were obtained from Australia through the courtesy of Dr. Magee and Dr. Watson. A small area was sown to rye at the Agricultural Research Station, Nanjanad in the Nilgiris. When the crop came into flower, spray inoculations with the pure culture of the fungus were carried out. In a month evidences of infection were present. Analyses of these sclerotia by the Research Officer of the Madras Medical College showed that the quality of the ergot was good. Encouraged by these results a scheme for the production of ergot was submitted to the Madras Government in 1942 and was sanctioned for one year. A special staff was appointed and stationed at the Agricultural Research Station, Nanjanad. Various experiments were started to find out the conditions favouring maximum ergot production and the varieties of rye most suitable for this purpose.

It was found that rye could be successfully grown only at an elevation of 5,000 feet and above on the Nilgiris and that sowings should be conducted in April or July for obtaining good yields of ergot. The weather conditions prevailing at the flowering time and for six to eight weeks thereafter determined the intensity of infection. Misty or showery weather at this period was the most favourable. If, on the other hand, dry or rainless conditions were prevalent, infection was poor and the yield of ergot was low.

At the time of sanctioning this scheme, doubts were entertained in some quarters that ergot introduction on the Nilgiris may be injurious in that the fungus may pass on to other cereals and grasses and form a source of stock poisoning. The experiments conducted on the Nilgiris set at rest all doubts on this score. The fungus did not pass on to many of the grasses, barley, oats, samai (*Panicum miliare*) and *Korali* (*Setaria glauca*) when artificially infected. Only two grasses (*Vulpia myuros* and *Avenastrum asperum*) took infection. Even here the spread was insignificant. Furthermore, it was found that several species of *Claviceps* were already present in a number of grasses on the Nilgiris, Palnis, Wynaad, Coimbatore, etc.

Based on these results a scheme for large-scale production of ergot was sanctioned in 1944 for a period of three years and was further extended to 1951. The object of the scheme was to produce large quantities of ergot intended mainly to meet the requirements of the Indian Dominion and to have a drug of dependable quality. A laboratory was established at Ootacamund for the production of the cultures of *Claviceps purpurea* required for spray inoculation. The target of production was kept at 2,000 to 2,500 pounds of ergot per annum. Experience in previous years had shown that the yield of ergot varied considerably depending on several factors, and at a conservative estimate rye grown over 90 to 100 acres was expected to give this yield. Being

a new venture to some leading ryots, a subvention of Rs. 70 per acre for growing rye, carrying out spraying and harvesting was offered in order to induce them to take up ergot production. The harvested ergot was purchased at Re. 1–4–0 per pound from the ryots. Two years later, this system was modified, as the profits available to the growers were not sufficient to attract reliable growers. The subvention was abolished and it was decided to purchase the ergot at Rs. 12 per pound of dry ergot. The seed, cultures, spray equipment and technical advice were offered free to the growers. Neither of these methods has had the desired effect. It is now felt that a separate Government Farm is necessary so that all the operations can be carried out in time to ensure maximum yield instead of depending on the caprices of growers who always bestow more attention on potato and vegetable crops than the rye grown for ergot.

The experience over the last six years has shown that the Nilgiris plateu and Kodaikanals are well suited for ergot production. Sowings of rye have to be carried out in time to ensure the opening of the flowers during the monsoon and not in dry seasons, in order to obtain good harvests of ergot. Proper care in the cultivation of the crop and timely spraying with satisfactory spore suspensions are necessary for good infection. Yields up to 100 pounds of ergot per acre have been obtained. Fields situated on the tops of hill or exposed to strong winds are not suited for ergot production. Low-lying areas and places where overhanging mists are common, would appear to be the most suitable. Since large quantities of water are necessary for spraying, economic considerations would demand that suitable water sources are available in the immediate neighbourhood of the fields. Addition of sugar and molasses to the spore suspensions has improved infection during certain seasons, but when optimum climatic conditions prevail, this treatment does not result in increasing infection.

The cultures of the fungus are multiplied on sterilized rye grains. Good sporulation is evident a month after inoculation and such cultures are to be used for preparing the suspensions. The spray inoculation should be timed to synchronize with the flower opening in rye. About 40 to 50 bottles of culture are required to spray an acre eight to ten times. Since the flower opening is spread over five to six weeks, sprayings have to be carried out every third day to ensure maximum infection.

At the present wage levels, the cost of production is about Rs. 130 per acre. Assuming an yield of 20 pounds per acre, the grower can realize a profit of Rs. 110 per acre (with more profit if the yield is higher). The cost of production given above does not include the cost of the culture, spraying equipment, etc., which are supplied free by the Government. Ergot production being a specialized venture, the growers on the Nilgiris cannot be expected to provide these facilities for themselves.

The efficiency of ergot depends on the alkaloids contained in the sclerotium. There are a number of these such as ergotoxine,

ergometrine and ergotinine but the quality is determined by the ergotoxine and ergometrine content. The B.P. standard for the drug is 0·2 per cent of ergotoxine in the crude ergot. The alkaloid content varies with samples and depends on the strain of the fungus, the age of the product, the conditions of drying and storage and sometimes on the variety of the host plant. Ergots produced in different countries differ in their alkaloidal content. Spanish ergot which was considered to be the best, has an average content of 0·22 per cent, Russian ergot has only an average 0·06 to 0·1 per cent. The quality of ergot produced in this State has been considerably improved. When first introduced, the average alkaloid content was only about 0·19 per cent. But by the selection of individual ergots having higher alkaloid content for bringing the fungus into culture and by utilizing such cultures for inoculation purposes, the alkaloid content of the produce has been stepped up to an average of 0·4 per cent. Application of manures to the rye crop does not improve the quality of ergot.

Ergot is easily infested by insects and also spoiled by storage under moist conditions. When dried thoroughly in the Sun and stored in moisture-proof containers it can however be stored without deterioration for one or two years. It contains about 25 per-cent of fat. Its keeping quality is improved after defatting. Pharmaceutical firms process the ergot into *Ergota preparata* and *Extractum ergotæ liquidum* for oral administration and purified extracts of the alkaloids are prepared for injection.

The results of the scheme over the last seven years have shown that ergot production can be undertaken with considerable profit, on the Nilgiris and Palanis. Adequate technical knowledge and reasonable care in the cultivation of the crop are, however, essential to secure maximum production.

" FOOD YEAST " MANUFACTURE.

Yeasts are minute one-celled fungi of great economic importance. These are widely distributed in nature and generally flourish on sugary media causing fermentation. These are different kinds of yeasts used for different purposes in different parts of the world. *Saccharomyces cerevisiæ*, Hansen is largely used in the brewing industry. A number of strains of this species have been propagated for the fermentation and manufacture of different kinds of beer, ale, etc. At one time the yeast produced in the breweries and distilleries was made into pressed yeast used in bakeries, but at the present time compressed yeast is specially cultivated in ærated wort. A more satisfactory product is obtained by this method and supplied to bakeries.

'Food yeast' is obtained from a type of non-spore-forming yeast and the product represents the dried cells of *Torulopsis utilis*. This is rich in high class protein and is also one of the

best sources of the vitamin B complex. Brewer's yeast also contains these substances, but the 'food yeast' is preferred for nutritional purposes on account of its superior flavour and palatability.

The use of special forms of yeast as food is not new. The Germans are reported to have manufactured annually thousands of tons of food yeast during the two World Wars for the supply of protein to their people. Interest in the possibilities of food yeast manufacture has been evinced by other countries also in the hope of improving the dietary of the population. Food yeast is of particular value to the people in the tropics whose staple food consists of highly polished rice, highly milled maize and other starchy food stuffs, all deficit in vitamin B.

The Mycology Section initiated experiments on the manufacture of food yeast by cultivating it on wort made from sugarcane molasses following the method adopted at Teddington by Theysen in the year 1943. A small laboratory plant was set up, being rigged up with the available equipment, not entirely ideal. The culture of the fungus was obtained from Teddington through the help of the Head of the Division of Mycology, Indian Agricultural Research Institute, New Delhi. The molasses required for the preparation of the culture medium were purchased from the East India Distilleries, Ltd., Nellikuppam. The equipment used in this early stage for æration of the wort was anything but satisfactory and consisted of an iron tube with radiating arms at the bottom, the arms being pierced by fine holes.

Marked success was, however, achieved even with such methods and food yeast of a good quality was produced, which was highly appreciated by medical and nutrition specialists.

Analyses of the food yeast have given the following composition :—

	PER CENT.
Moisture	8·23
Ash	11·51
Crude protein	43·63
Ether extractives	0·76
Crude fibre	0·28
Carbohydrates (by difference)	35·59
Total ..	100·00

The vitamin assay of the samples by the Director, Nutrition Research Laboratories, Coonoor, gave the figures noted below :—

Thiamin	35·3 μ gm. per gram.
Nicotinic acid	124·5 μ gm. per gram.

Riboflavin was not determined but is known to run parallel to nicotinic acid values.

The process consists of inoculating the culture medium with live food yeast and ærating the medium for a period of eight hours. During this period the yeast multiplies and grows utilising the food materials in the medium. Very little of alcohol is formed during the process. At the completion of the fermentation the yeast is allowed to settle and separate from the supernatant liquid. The cream-like sediment is contrifuged and is repeatedly washed to remove all unpleasant odour. The sludge is removed, passed through a vermicelli press, dried at 50°C. and then powdered. The washed cream can also be passed through a roller drier and the dry powder collected.

A sample of the molasses to be used is analysed to find out the sugar content. The molasses is clarified and sterilized. The sterilized molasses is drawn into the fermentation vat and diluted with water to bring down the concentration of sugar to 0.50 per cent. Measured volumes of ammonium phosphate solution (prepared by mixing together aqueous solution of ammonium sulphate and aqueous extract of double super-phosphate in definite proportions) is added to the molasses solution to supply the nitrogen and phosphorous requirements of the yeast. Seed yeast is mixed with the wort using about one per cent by weight of wet yeast. The wort is then ærated, by forcing filtered air through ceramic aerators kept near the bottom of the vat. Air is forced out in very fine bubbles producing a foam-like effect which has given better results than when the wort is ærated through tubes with bigger holes.

During the fermentation, acid is formed and the wort tends to become more and more acidic. The best results are however obtained if the reaction of the wort is maintained at pH 4·8. In order to keep the reaction at this level liquor ammonia is usually added to the wort. Experiments conducted at Coimbatore have however shown that if a continuous flow of a solution of ammonium carbonate of known strength could be kept up, the reaction would remain constant at the required level. The optimum temperature was found to be 30° C. It is advantageous to add the molasses and ammonium phosphate in three charges at two hours' intervals than in one lot. The æration is continued for eight hours after which the wort is allowed to settle.

An outturn of 11 to 14 per cent of dry yeast on the quantity of sugar used has been obtained. In other countries a much higher outturn has been reported. Research is in progress to devise ways of increasing the outturn.

Based on the results of the laboratory plant a pilot plant has been installed to work out the economics of food yeast production. This plant has a capacity of producing six to seven pounds of dry yeast per day. The fermentation vats are made of aluminium. This is not ideal as aluminium is liable to get corroded

in a short time. Stainless steel equipment would be more satisfactory. The production costs can be reduced to a large extent if the manufacture of food yeast is carried out near a sugar factory, as this will reduce the transport charges on molasses.

Clarification of molasses before sterilization leads to improvement in the production of yeast. Several methods were tried and the lime process gave the most satisfactory results and could also be easily adopted. Trials with different periods of duration of æration showed that eight hours æration gave the maximum production.

It has been reported from other countries that commercial production of food yeast is profitable. In the pilot plant at Coimbatore the cost of production works out to nearly Rs. 3 per pound which is rather high. But as already stated, if the manufacture is undertaken as an adjunct to a sugar factory, the overhead charges and transport charges can be considerably reduced and the cost of production can be brought down and yeast made available at a cheap price. The produce from the pilot plant at Coimbatore is being used by several hospitals and individuals. The present production is barely sufficient to meet the demands of three or four hospitals in Madras and the mofusil.

ANNATTO-DYE.

Bixa orellana L. (the source of Annatto-dye) is a quick growing plant developing into a large bush or a small tree. Its original home was in Tropical America but it is now grown in Godavari district concentrated in the neighbourhood of Tuni. Stray plants can be seen in other parts of the State having been introduced mostly by the Agricultural Department. It can be grown at different altitudes ranging from sea level to 2,500 feet. (Kallar and Burliar) but thrives well only in a humid climate. A deep, loamy soil is preferred. It is propagated from seed and starts bearing from the third year onwards. Mature trees yield more. An average yield of 5 cwt. of seed per acre can be expected.

Clusters of capsules with fleshy spines are formed at the ends of branches. When dry these fruits burst and expose the bright crimson coloured seeds. The latter have a fleshy crimson covering which yields the dye. The fruits are collected when nearly ripe, dried and the seeds extracted. The seeds are dried and sold as such as 'annatto' seeds. But sometimes the fresh seeds are pressed into annatto paste or cakes. The dry seeds are preferred.

This dye is extracted by soaking the seeds in olive oil (30 oz. seeds in 8 oz. olive oil). It is red in colour and soluble in alcohol and alikaline solutions. The dye is used for colouring silk and sometimes butter and cheese. The dye is fugitive.

Experiments conducted at the Agricultural Research Institute, Coimbatore, on the different methods of extraction of dye for colouring butter have shown that sesame oil, ghee, groundnut oil and coconut oil are capable of extracting the dye. The oil extracts are not, however, comparable in dyeing power to the imported dye when added to butter. Furthermore they impart a bad flavour. Other solvents were also tried. Strong extracts were obtained by the use of aqueous solution of ammonia. Glycerine and solution of borax and sodium bicarbonate dissolved less of the dye. The ammoniacal extract proved to be the best. It was prepared by rubbing the required quantity of annatto (extracted from the seed by steeping it in 1 per cent solution of sodium carbonate) for 24 hours and then rubbed in a mortar, washing repeatedly with further portions of the alkali until all colouring matter is removed; the coloured solution is next strained and enough of dilute hydrochloric acid is added to this to precipitate the dye; the precipitate is filtered, dried in an oven and crushed in a mortar with a small quantity of strong ammonia. This is filtered and a clear dye solution is obtained. A preservative such as chloroform is added to prevent mould growth. Drops of this are added before pasteurizing the cream and good results are obtained. Being a vegetable dye it may be safer to use this in place of synthetic ones for colouring butter, cheese and other food products. It is however doubtful if it can stand competition against synthetic dyes for colouring textiles.

STARCH AND STARCH PRODUCTS.

Commercially starch is obtained from various sources. Cereals (like maize) and potatoes contain large proportion of starch in the grains or tubers respectively; but except in certain countries they are more often consumed as such for food and not utilized for the manufacture of starch. Other plant sources are, however, utilized for the preparation of starch. The most important of these, cultivated in South India, are tapioca (*Manihot utilissima* Pohl), West Indian arrow-root (*Maranta arundinacæ L.*) and East Indian arrow-root. (*Curcuma aggustifolia* Roxb). The Sago palm (*Arenga saccharifera* Labill) of Malaya is cultivated in some parts of India and is the source of sago.

Tapioca.—This is cultivated in many of the districts of the State of Madras and Cochin-Travancore. The plants are raised from cuttings. Several varieties are grown. The tubers of all the Varieties are reported to contain a cyanogenetic glucoside, but the sweet varieties are preferred as being less harmful. Large quantities of starch are present in the tubers. The yield of tubers from an acre has in some cases reached 30,000 lb. These tubers are used directly as food after boiling. Various other preparations are also made out of them. The tubers are scraped, washed and then converted into pulp by mechanical contrivances (passing between rollers, etc). The starch present in the pulp is then washed out in changes of water, decanted and dried. The starch thus obtained

is of a greater degree of fineness than when the roots are directly powdered. This starch is sometimes converted into pearl or bullet tapioca which is used in place of sago. In the manufacture of this type, the crumbled starch is transferred to hammock-like contrivances of canvas, about 4 feet by 2 feet in size, suspended from the roof or a frame and rocked to and fro regularly. This causes the starch grains to adhere into small pearls and when the required size is attained they are poured out. The material is later graded by passing through galvanized iron sieves. This product is now prepared to a large extent in Salem district.

Maranta arundinacea (West Indian Arrowroot) which is a native of Tropical America, is now cultivated in parts of Malabar. A good rich soil and plentiful supply of water are necessary. Clusters or rhizomes are formed at the base of each plant. These rhizomes contain up to 20 per cent of starch. The rhizomes are washed well and scraped with a knife to remove the rind. They are then converted into pulp and thrown into a vessel of water. The fibrous portions are again pulped and washed in water. The milky fluid obtained from these washings is strained through coarse cloth and allowed to settle. The supernatant liquid is drained away and fresh water added to the sediment. This is stirred well and strained through a finer cloth and allowed to settle. The clear liquid is drained off and the white sediment is removed and dried on sheets of paper. The resulting powder is the arrowroot starch.

Curcuma angustifolia is an indigenous plant resembling turmeric. It is largely grown in the West Coast and the Circars. At the Saidapet experimental farm 3,944 lb. of tubers were obtained from an acre. But at Araku Valley only 900 lb. of tubers were harvested.

The method of preparation of starch from the tubers is on the same lines as in *Maranta.* One pound of starch is obtained from 8 to 10 lb. of tubers.

Arenga saccharifera Labill is a native of Malaya and yields the true sago. It is not very common in this State. Two attempts were made to grow this palm at the Agricultural Research Station, Kasargod, but on both these occasions the seeds failed to germinate.

Utilization of groundnut husk.

Groundnut husk (Peanut shells) is a waste product which is obtained when the nuts are shelled. Groundnut being one of the major crops in the State, groundnut husk is available in plenty in localities where the nuts are shelled. At present, the shells are mostly wasted, though in some localities it finds a ready use as fuel for boilers and brick-kilns. The shell ash which contains about 1·5 per cent of potash and 3 per cent lime is used as a manure. Groundnut husk is sometimes applied to heavy soils especially in paddy lands under wet cultivation to improve the physical texture

of the soil. The application of husk is said to be particularly beneficial for alkaline soils in some localities in this State as it is said to correct alkalinity to certain extent. The beneficial effect may be attributed to the fact that the application of the husk makes the soil more open, thus ensuring better drainage. This may help in washing down the injurious salts to deeper layers.

The Agricultural Department carried out a few items of work as a preliminary investigation on the possibilities of utilizing groundnut husk.

Manurial value.—Samples of groundnut husk received from Tindivanam and Guntakal were analysed for their manurial value. The results obtained are given in Statement I.

STATEMENT I.

	Tindivanam sample. PER CENT.	*Guntakal sample.* PER CENT.
Moisture	10·22	4·93
Loss on ignition	84·82	88·25
Insolubles	2·36	3·56
Nitrogen	1·23	0·99
Phosphoric acid (P_2O_5)	0·16	0·14
Potash (K_2O)	0·54	0·47

Utilization of groundnut husk as a bedding for cattle.—A few experiments were carried out at the Agricultural Research Station, Nandyal, on the utilization of groundnut husk as bedding for cattle. The results of analysis of manures obtained by the loose box and byre system are given in statement below :—

	Loose box.	*Byre.*
Moisture	44·60	30·80
Loss on ignition	36·62	57·34
Insolubles	10·10	9·50
Nitrogen	1·10	1·24
Phosphoric acid	0·42	0·39
Potash	1·68	3·16

Compost making.—Groundnut husk along with other waste materials like prickly-pear, cotton waste, etc., was tried as a basic materials in the preparation of compost. Fifty pounds of bone-meal, 200–300 lb. of half-fermented cattle manure and a small amount of urine were used per ton of the dry material to supply enough quantity of nitrogen and phosphoric acid to accelerate fermentation and hasten the decomposition of the basic materials. The results of analysis of two composts prepared in this way are given in the following statement :—

	Prickly-pear and groundnut husk.	*Cotton waste and ground nut husk.*
Moisture	30·99	12·45
Loss on ignition	13·25	46·23
Insolubles	44·25	35·82
Nitrogen	0·37	1·42
Phosphoric acid	0·37	0·92
Potash	0·22	1·11

Preparation of activated carbon from groundnut husk.—Trials conducted to investigate into the possibility of utilizing groundnut husk for the manufacture of activated carbon showed that it was possible to prepare good quality active carbon from the husk.

The method first adopted was to soak the husk in one to two per cent solution of caustic soda for one week, then to wash it free from alkali, dry and char it. The powdered and sieved charred stuff was heated in closed pipes at 600°–700°C. for eight hours. It was then again washed and dried. The active carbon thus prepared compared favourably with that prepared from paddy husk. Although the product obtained in laboratory scale trials was satisfactory, large-scale trials did not yield satisfactory results. Subsequently treatment with zinc-chloride was substituted in place of caustic soda (1 : 1 ratio). The powdered husk was soaked in zinc-chloride solution for six hours, charred and heated for two hours. The resulting product was found to be even superior to activated carbon prepared from paddy husk. Starting with 100 gms. of the husk, 50 gms. of activated carbon was obtained. The method, however, was not economical.

Groundnut husk as a dunnage material.—As a dunnage material in groundnut godowns groundnut husk has shown itself superior to other materials like paddy husk, railway cinders, etc., now in use. The groundnut husk is found to provide a soft bedding material and the bags stacked on it do not get damaged to the same extent as on others.

The lines on which investigations on the possibilities of utilizing groundnut husk may be carried out are given below: (*a*) as a roughage in prepared cattle food, (*b*) as a diluent in fertilizers, (*c*) as a bedding for cattle, (*d*) as a fuel under shelling plant boilers. (*e*) in the production of magneisa plaster, tiles and fibre concerete in place of saw dust and wood chips, (*f*) as a polishing medium in tin plate manufacture, (*g*) in the manufacture of explosives and as a source for *pentosans* and for the manufacture of acetone, alcohol and acids and (*h*) as a source of cellulose.

VEGETABLE OILS FROM INEDIBLE SEEDS.

Tobacco seed oil.—The seeds of tobacco (*Nicotiana tabacum*) contain an oil which was not being extracted on any appreciable scale in India. The Madras Agricultural Department has conducted investigations on the extraction and use of this oil.

Virginia tobacco is grown in Guntur and neighbouring districts on an area of over 125,000 acres. This is freely allowed to seed. An average yield of 175 lb. of seed is obtained from an acre. Though the use of the oil as a salad oil and for the preparation of varnishes, etc., had been known in Europe for a long time, in India most of the seed was till recently being burnt as fuel. But the results of the investigations carried out by the department showed that the oil could be profitably extracted from the seeds

and that it could be used for cooking, for burning and for soap-making. It could also be utilized in the manufacture of paints and varnishes. The cake has been found to be an excellent cattle feed.

An outturn of 9,800 tons of seed capable of producing 2,450 tons of oil per year can be expected from the Circars. The oil is extracted by crushing in country *chekkus* or rotary mills. Another method of extraction consists in powdering the seeds in mills and later crushing the powdered material in screw presses.

The seed contains 33 to 38 per cent of oil and 25 per cent can be extracted in country *chekkus*. The cold drawn oil is thin, light yellow and of an agreeable smell and taste comparable to gingelly oil. The hot drawn oil is slightly bitter. The oil is free from harmful substances like nicotine and has a specific gravity of 0·9232.

Economic utilization of press mud—Press mud as a fertilizer.—The mud can be used either as such or after the extraction of wax. Only the sulphitation mud is useful for composting and not carbonation mud even though the latter has a low C : N ratio (11 :6) while the former has a high value of 31 for C/N. Among the various methods of composting, the hot fermentation process is said to be the most economical. The loss of dry matter recorded was nearly 25 per cent and the resulting compost contained 1·2 per cent nitrogen.

Owing to the high P_2O_5 content of the press mud, its application at 5 to 10 tons in the dry form per acre to soils deficient in phosphates, has proved beneficial. Press mud, as it contains both P_2O_5 and N. constitutes a complete fertilizer. The lime and organic matter present therein definitely improve the soil tilth.

Organic solvents.—Preliminary experiments with press mud have shown the presence of sulphur compounds in some of the fractions obtained by the dry distillation of the mud. It would appear that a solvent for the cane wax is among the fractions obtainable.

Other products from press mud.—Press mud forms an ingredient in the briqueting of molasses with begasse, etc. The addition of press mud inhibits moisture absorption and thus stabilizes the briquettes. The briquettes prepared from a mixture of molasses, coal dust, begasse and press mud form an excellent source of fuel in the factory. They are also easy to handle both during transit and in the factory.

Manufacture of yeast and of a vegetable gum substitute is also possible.

Some commercial uses of pectins in general.—Tamarind seed is a valuable source of pectin or protein-like compounds which are used in the manufacture of adhesives, emulsifying agents for essential oils, gelatinizing agent in food products, ingredients of jam, jelly, candy, etc., also in the preparation of greaseless ointments, as a filler in soap industry, for thickening rubber latex, and above all in textile industry as an ingredient for viscose spinning solutions.

Separation of pectin.—The seed coat is not easily separated. So the seeds are parched on hot sand taking care not to char them. Then they are pounded and winnowed. The cleaned kernel is washed well with water and then soaked in and rubbed with a thin paste of lime. It is then washed, dried in the sun, and finely powdered (to pass through 80–100 mesh). The oil can be removed by soaking in petrol. A thin paste of the above material (ratio of 1 : 10 with water) is poured on to 30–40 times its weight of boiling water and boiled for 30 minutes, cooled and strained through cloth. This can be bleached by SO_2. A whitish liquid is thus obtained, which on centrifuging deposits a finely suspended fibrous matter and a large proportion of the albuminoids. The solution is separated from the above and concentrated under reduced pressure. It can also be dried by passing over a steam heated surface. This material is pure enough for most of the purposes.

Manufacture of 40 per cent nicotine as a solution of nicotine sulphate in water.—The maximum extraction can be achieved by steam distillation of a mixture of tobacco and lime. The extraction will be economically complete in one and a quarter hour. The spent tobacco will have a nicotine content of approximately 0·45 per cent. This method is applicable to tobacco containing a minimum of nicotine of 1·5 per cent. The economics of the process are entirely dependent on the cost of production of steam or cheapness of fuel.

CHAPTER 26.

LIVESTOCK, DAIRY AND POULTRY.

Livestock improvement—Breeds of cattle—Ongole, Kangayam, Alambadi—Lines of improvement—Chintaldevi Farm—Hosur Cattle Farm—Cross-breeding with English breeds—Buffaloes—Murrah breed, work at Coimbatore and Lam Farm, Guntur—Feeding trials and standards—Rations for cattle—The dairy industry—Milk production in the State—The Coimbatore College Dairy—Records of pedigree and milk yields—Ghee production and standards—Bacteria in milk—Sheep breeding—Bellary breed, Bikaneer breed, cross-breeding for improving quantity and quality of wool—Poultry work—Early breeding studies at Saidapet—Import of breeds from abroad—Poultry units at the Agricultural Research Stations.

Introduction.—India possesses the largest cattle population of any country in the world. The total cattle population of India is estimated at 245 millions, while it is 58 millions in the United States of America, 65 millions in the United Socialist Soviet Republic and only 7 millions in Great Britain. So far as Madras is concerned the total cattle population according to the cattle census taken in 1944 was 22 millions (22,644,239). In addition the State has 40 millions other livestock, comprising over 10 million sheep, six million goats and the remaining under horses, ponies, mules, camels, and pigs. This total number is greater than that for any other State in India and is about one-fourth of the total number of livestock in India.

Agriculture in this State is mainly dependent on cattle labour. Cattle are required for cultivating millions of acres, for lifting water from wells and for transporting agricultural produce from the field to the market. Milk, though important, is a secondary consideration. The Royal Commission on Agriculture in India had observed that " in most parts of the world cattle are valued for food and for milk; but in India the primary purpose of the cattle is as draught animals for the plough or the cart. Without the ox no cultivation could be possible. Without the ox no produce could be transported."

The productive value of the livestock industry in India is not commensurate with the numbers because of the poor quality of the Indian cattle. " India having acquired so large a cattle population and the size of the animals in many tracts having fallen so low, the task of reversing the process of deterioration and of improving the livestock is a gigantic one. But on improvement of cattle depends the prosperity of agricultural production. Poor cattle affect agricultural efficiency. Bad bullocks lead to bad cultivation and poor returns. The poor return in turn leads to their neglect by the ryot and the cattle deteriorate further.

The two important factors in cattle improvement are feeding and breeding. The Royal Commission on Agriculture stated that " no substantial improvement in the way of breeding is possible until the cattle can be better fed ". In this State, it has been estimated that 90 per cent of livestock depend upon arable land and its bye-products and only 10 per cent have access to forest grazing. The fodders available in this State are mainly straws of cereal crops, residues of leguminous crops, grasses from natural pastures and dried forest grasses. Oil-cakes, cotton seed and bran form the concentrated feed for cattle. The Madras State is deficit in all these items which are imported from other States for feeding cattle. Fodder-growing for feeding livestock is not generally practised owing to the long-established agricultural practices and does not find a place in the usual rotations. This is due to the fact that there is pressure of the population on the land and the pressing need for the production of food-crops as a first charge upon the agricultural economy of the State. The operations of the Agricultural Department have demonstrated the possibility of the successful inclusion of a fodder crop in rotation in places where irrigation facilities are available. With the propaganda and the technical help given by the Agricultural Department, ensilage of grass, improvement of natural pasture lands, introduction of perennial fodder grasses and fodder crops, etc., contribute to the attempts made for improving the feeding of livestock in this State. The Provincial Fodder and Grazing Committee has also initiated several schemes aiming at the improvement of feeding facilities for the livestock. The Forest department offer certain grazing facilities in Government forests by which stock owners are given concessions in the matter of grazing their stock in the forest areas.

Before mentioning the work done on breeding of livestock, it is necessary to understand the existence of certain well defined breeds of cattle. Madras can boast of three good breeds, the Ongoles, the Kangayams and the Alambadies. The Kangayam breed in Coimbatore district, and the herd of the Pattagar of Palayakottai in particular, have won all-India fame as examples of careful breeding. The Ongole is a dual-purpose animal useful both for draught and milk. The breeding tract of the Ongoles is Guntur and Nellore districts. The Alambadies form a good breed, though poor milkers. The breeding tracts are Kollegal taluk in Coimbatore district, parts of Salem and borders of Mysore State chiefly along the banks of the river Cauvery. The Hallikar breed, the chief member of the Amrit Mahal cattle of Mysore, has its centres of breeding in Tumkur, Hassan and Mysore districts. The other minor breeds of cattle in the State are (i) the Barghur hill breed found in Bhavani taluk in Coimbatore district, (ii) the Pulikulam or Jellicut breed found in Madurai district, (iii) the Tanjore polled cattle found in southern parts of Tanjore and (iv) the West Coast cattle which are a class by themselves.

In the direction of improvement in cattle-breeding, the first and foremost action taken by the department was the appointment in 1916 of a separate wholetime officer designated as Deputy Director of Livestock. Then followed the establishment of stock-raising farms. To i mprove the Ongole breed, the Chintaldevi Cattle Farm was started in 1918. Another farm for breeding buffaloes was opened near Guntur in 1923 and a third for Hallikars and Kangayams was established at Hosur in 1924. The broad lines on which the work in the livestock section was carried on may be stated as (i) management of stock farms in localities in which good breeds of cattle existed, (ii) preservation in such farms of valuable strains of indigenous cattle and the distribution of good stock therefrom, (iii) formulation of systematic measures to improve the draught and milk qualities of cattle by selection and crossing and (iv) the formation of milk record societies and investigation of several other problems connected with milk. The chief activity in the districts was, among others, the distribution of good breeding bulls of known pedigree to individuals, societies, municipalities, district boards and Veterinary Hospitals, under the 'Premium' scheme, with the object of improving the local cattle.

A detailed account of the achievements made in the feeding and breeding aspects of livestock, sheep and poultry by the Livestock section of this department up to 1938, when it was transferred to the Animal Husbandry Department, is given in the succeeding paragraphs.

The Ongole breed.—The weakest link in the livestock industry of the State is the paucity of breeding bulls. The *Brahmini* bulls dedicated to temples on the death of rich people and the animals maintained by a few people, specifically for breeding purposes, are the only male breeding stock. They are on the whole few in number and do not meet the full requirements. The demand is met to an extent by the scrub bulls and the immature bull calves in the villages. This is not satisfactory. It was therefore proposed to encourage the maintenance of breeding bulls and as a first step, cattle farms were proposed for producing breeding bulls and for the improvement of stock. The first of these farms was started at Chintaldevi in 1918, for the improvement of the Ongole breed of cattle.

Chintaldevi is an interior village in Kavali taluk of the Nellore district and is 38 miles by road from Kavali Railway station. Chintaldevi has the influence of both the south-west and the north-east monsoons, which are erratic in this part of the country. The rains fall in some years while pouring in others rendering the season unpredictable. Hower, cattle throve very well here, in the farm.

The farm started with a foundation stock of 46 cows and 5 breeding bulls. Irregular breeders and poor milkers were weeded out year after year and 25 cows of the foundation stock were finally retained. The cows were reared carefully and unthrifty

heifers were sold off. The best heifers were mated to selected bulls and it was programmed to build up good stock by rigorous culling combined with selected and careful mating.

After 13 years of selection work, stock was taken of the performances of the farm-bred animals to measure the volume of improvement. The average daily milk yield had risen from 9·8 lb. to 11·5 lb. The highest milk yield of farm-bred stock was 7,190 lb. in a lactation, with a daily average of 21·5 lb., against 5,422 lb., and 14·1 lb., respectively of the foundation stock. Ten farm-bred animals yielded over 5,000 lb. of milk in a single lactation.

The average dry period of the foundation stock was 177 days and that of the farm-bred stock was 147 days. Heifers calved at the age of three years and four months, when compared to four to four and a half years of the village-bred animals. Side by side with these improvements it was seen that the farm stock had loose horns and weak legs, and the factors that induced these defects could not be determined. The fodder production in the farm was not satisfactory and the farm was closed in 1932 as a measure of retrenchment. The farm stock was transferred to Lam Farm in Guntur district where a nucleus herd is maintained.

Some Ongole animals were taken to Hosur to see how they would fare there. The general level of milk yields got reduced. Calves at birth weighed less and the bulls did not attain the same stature and finish finally, as at Chintaldevi.

The Kangayam breed.—This is the next important breed of the State, bred in Coimbatore district. The breeding of the Kangayams was taken up at the Livestock Research Station, Hosur, in 1925. The foundation stock of 170 cows was purchased during the years 1925 and 1928, with the object of building up a herd breeding true to type and good at draught work, and of producing breeding bulls for distribution in the villages. The improvement of milk yield without any impairment of the draught qualities was also kept in view. The Kangayam animals throve well at Hosur and responded to good feeding and there was a slight improvement in calving intervals, from 15 to 14 months on the average and in milk yields from a daily average of 6·2 lb. to 6·6 lb. The bulls were fit for breeding at two years and six months. The general feeding was grazing and a little hay; cows with calves at foot were given some concentrates also. Kangayams appear to be the most economical animals to breed at Hosur. Breeding bulls are being distributed from Hosur widely over the southern districts of the State year after year.

The Sindhi breed.—The Sindhi breed comes from the south-western parts of Sind and is one of the best dairy breeds in the country. The cows are good milkers and the bullocks are fair

Plate 158.—Kangayam breeding bulls.

Plate 159.—*Kangayam work bullocks.*

draught animals, slow but steady at work and capable of pulling heavy loads. A nucleus stock was introduced at Hosur in 1923 with the object of producing and supplying cows for City milk supply. The animals did well at Hosur, even on scanty rations. They do well almost all over the State and are found to be capable of adapting themselves even to the trying heavy rainfall conditions prevailing in the West Coast. About 70 animals formed the foundation stock, which gave a daily average milk yield of 11·9 lb. The yield was maintained at this level by the farm-bred stock also. The herd is being used for production of breeding bulls for supply to the districts.

Cross-breeding at Hosur.—The indigenous cows are poor milkers and City milk supply requires the maintenance of heavy milkers for the production of milk at economic levels. It was considered that by mating the indigenous cows with bulls of European milk breeds, a cross-bred high-yielding stock could be built for City milk supply. Pedigreed Ayreshire bulls were imported and mated with Sindhi and Sanıwal cows. Later the cross-bred bulls and cows of the same generation were mated, first generation bulls and cows together, second generation bulls and cows together and so forth to maintain 50 per cent of the imported blood for maintenance of milk qualities and 50 per cent of the indigenous blood for maintenance of resistance to diseases and adverse hot climatic conditions, in the resulting stock.

The experiment on cross-breeding was done at the Military Dairy Farm, Bangalore, from 1919 to 1923. The Livestock Research Station, Hosur, acquired 32 cross-bred cows from the Military Dairy Farm in 1923 and continued the cross-breeding work for some time. During the course of the experiment, 222 calves were born, 27 in the first, 60 in the second, 97 in the third, 35 in the fourth and 3 in the fifth generation. Out of the cross-bred calves, 106 died of pneumonia, enteritis, rinderpest vaccine reaction, johnes disease, blackquarter and pyroplasmosis, in the order of their incidence. Even the second and third generation calves did not grow as vigorously as the first generation and there appeared to be a progressive decline in vigour. This was attributed to the weaning of the calves at birth and hand-feeding them artificially, probably at the wrong temperature and with incorrect amounts. The young calves were subject to scour, from which they recovered rather slowly. Ringworm was also troublesome and responsible for retarted growth.

Surplus bull calves were sold or castrated and used as work animals. Cows poor in milking and irregular in breeding, were eliminated from the herd. F 1 cows, that is cows of the first generation crosses, calved on the average at 32 months of age, F 2's at 37 months, F 3's at 38 months and F 4's at 36 months. F 1's gave an average of 5,021 lb. of milk per lactation, F 2's 3,296 lb.,

F 3s 3,626 lb. and pure Sindhies maintained under similar conditions for comparison gave 3,431 lb. The average daily yields of milk from the first to the last calving, inclusive of dry periods were 12·7 lb. 10·5 lb, 10·4 lb. and 7·2 lb., respectively for the above classes of animals. Cross-bred animals gave on the whole 3·2 to 5·5 lb. of milk a day more than the pure Sindhis over their entire milking life.

Though the first generation cross-bred animals were heavy milkers, subsequent generations tended to revert to the original Sindhi parent type in milk yield. The adult cows had a general satisfactory appearance, and were not subject to udder trouble like their original Sindhi parents Many of the cross-breds did not retain the first or second service and in spite of it their dry periods were less than that of the parental indigenous Sindhis. Bulls of the second and third generations developed weakness about the hind parts, a knocking of the hocks and a general falling off in level behind the shoulders. The cross-bred bulls were however good and quick at service.

The cross breeding experiments may be said to have given some valuable general guidance for the future. Improvements of stock requiries the elimination of a large number of animals not coming to the standards laid down and cross breeding work was hampered and limited by the few animals under the experiment. The cross-bred bulls were very disappointing. They had no humps practically, a serious defect from the point of view of the ryots, though they worked as well as the indigenous bullocks in Government farms. The cross-bred cows and calves could not stand on subsistence rations available under village conditions. The cross-bred cows were, however, economic milk producers and this is also the opinion of the Madras city milkmen. The milk yields and size of the cross-breds tended to revert to the level of the indigenous parent stocks after a few generations. Taking all factors into consideration, cross-breeding was abandoned as not being successful.

Cross breeding experiment at Hosur was a failure. Uncontrolled breeding with European stock is capable of doing irreparable damage among the existing local cattle. Yet, the possibility that Indian milch cattle might be improved by judicious mating with suitable breeds of European cattle at the hands of experienced breeders, is not to be ruled out.

Buffalo breeding.—Buffaloes are popular in South India, in view of their importance as producers of rich milk and ghee. Though the proportion of the buffalo-cow population is nearly 1 : 2, buffaloes account for more than half the milk production in the State. In view of this, steps were taken to improve the buffaloes from the early years. Murrah buffalo breeding bulls were maintained at the Agricultural College Dairy, Coimbatore from 1917 onwards and used for serving the local buffaloes of the

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Plate 160.—*A herd of Murrah buffaloes.* P. 1255

villages round about. The influence of the Murrahs on the size and milk yield of the local buffalo stock is distinctly visible. A number of Murrah buffaloes and bulls were also imported in course of time by private individuals at Coimbatore and they are helping to improve the local buffalo stock.

A buffalo breeding station was started at Lam, near Guntur, in 1923 and the Murrah herd at the Coimbatore College Dairy was transferred to Lam. New Murrah stock also was acquired for the station with the object of grading-up the local buffaloes, and producing better milkers and larger sized work animals. The station is being continued and cross-bred buffaloes of varying grades could be seen all over the Guntur district. The average milk yield of the Murrahs at the station is 4,800 lb. per lactation. The maximum individual record is 9,600 lb., with a daily average of 18·9 lb. of milk.

The Premium Scheme.—Livestock Research Stations were started with the object of raising good breeding bulls for distribution in the villages. These stations were limited in number and size and could not meet even a small fraction of the demand for breeding bulls. It was considered essential that private individuals and corporate and local bodies should be encouraged to maintain breeding bulls. Grants were made to local bodies for the purpose, on the number of breeding bulls maintained. This was not satisfactory in all the districts. In non-breeding areas the bulls were not maintained properly; the people had not the requisite knowledge and experience. Another defect noticed was that the bulls were distributed over wide areas and not concentrated and limited to definite zones, so much so the influence of these bulls was not very apparent.

A number of bulls approved by the Agricultural Department originally, and later, after 1938, by the Livestock and Animal Husbandry Department were maintained under the scheme. The bulls had to serve the cows of the neighbouring villagers also and perform a certain minimum number of services each year to entitle them to the premiums, which were paid in cash after verification of the entries made in the register of services maintained for the purpose. All these have helped to an extent to encourage people to maintain bulls specifically for stud purposes. The number of breeding bulls in the country to-day is less than what is required and the development of artificial insemination of cows as a method of getting over the paucity of breeding bulls remains to be explored.

Indian Herd Books.—As a preliminary to the establishment of All-India Herd Books and for recording the main characteristics of the principal Indian breeds of cattle therein, the Indian Council of Agricultural Research asked the local Government in 1935 to collect authentic information about the principal breeds in this State. It was considered that 'Kangayam' and 'Ongole' breeds

were the important breeds worthy of registration and information about these two breeds was furnished to the Council in December 1935, as also the following ranges in the sizes of the animals, on the average, with a light permissible deviation on either side.

	Ongole.		Kangayam.	
	Bull.	Cow.	Bull.	Cow.
Average height behind hump in inches	58½	52	50½	47½
Height at croup in inches ..	61	54½	54	50
Girth of chest in inches ..	82	68	76	65
Weight in lb.	1,250	900	1,100	800
Length of fore shank in inches	8½	8½	7	7
Milk yield per lactation in lb.	..	2,500	..	1,000
Maximum daily yield of milk in lb.	..	15	..	Not known
Days in milk	..	240	..	150
Frequency of calving in months	..	24	..	18

Studies of feed materials.—In addition to the improvement of animals, studies in the feeding of animals were also done with various materials available in the country and regular feeding schedules have been drawn up for all classes of livestock. The results of these studies are given in the subsequent sections.

Silage.—In other countries green fodder is preserved in the succulent stage and used for feeding animals during periods of grass shortage. Green feeding material is well packed in pits, covered over by a thick layer of earth so as to exclude air from the material, and is removed for feeding when required. The green material undergoes certain fermentative changes in the beginning and later remains unchanged for long periods. The succulency of the material is preserved and the flavour of the resulting silage is fruit-like, when the preservation has been done in the proper manner. There is a certain loss of material by rotting at the sides and the top. Silage making was tried at the several Agricultural Research Stations in the State and in certain villages adjoining forests, with hill grass, common green fodders and edible tree leaves. All these lent themselves for ensilage and silage making was found to be feasible.

Silage making can be advocated to be done in tracts where sufficient surplus grass becomes available during the monsoon periods. The loss sustained in silage making was generally near about 30 per cent and silage making would not therefore be an advantage where facilities exist for converting the green grass into hay.

Concentrated ration standards.—Of the feed given to animals, a part is utilised for carrying on the functions of the bodily organs and this part of the feed is called the maintenance ration. The feed supplied over and above the maintenance is used for providing energy for doing work, for producing milk, wool, etc., for making growth and for feeding the foetus in the womb. This part of the feed is called the productive ration. The quantities of feed of

various kinds required for the different classes of animals were worked out and found adequate and suitable for feeding the animals maintained at the various Agricultural Research Stations and they are given below.

It may be roughly stated that an adult cow or bullock requires about 15 lb. of straw, three lb. of concentrated feed, one ounce of mineral mixture and one ounce of common salt per day as the maintenance ration and that one lb. of concentrates should be fed for every three lb. of milk produced by the cow in addition to the maintenance ration.

Rations for cattle.

Class of animal.	*Groundnut cake.*	*Cotton seed.*	*Rice bran.*	*Dholl husk.*	*Mineral mixture.*	*Salt.*	*Suckling calves.* *Milk.*	*Suckling calves.* *Gruel.*	*Hand fed calves.* *Milk.*	*Hand fed calves.* *Gruel.*
	LB.	LB.	LB.	LB.	OZ.	OZ.	LB.	LB.	LB.	LB.
Work animals	2	1½	..	..	1	1	..	..	..	..
Breeding bulls	2	2	1½	..	1	1½	..	..	..	..
Dry cows	1	½	2	..	1	½	..	..	..	.
Milch cows giving up to—										
10 lb. milk ..	2	1½	2	1	1½	2	..	..	..	..
15—20 lb. " ..	2½	2	3	1½	2	2	..	..	..	..
20—25 lb. " ..	3	2½	2	3	2	2	..	..	..	..
over 25 lb. " ..	3½	3	2	3	2	2	..	..	..	..
Cow in calf ..	1	1	1	2	2	2	(six weeks before calving).			
Calves 1— 2 years ..	1	1	2	..	2	2	..	..	..	..
" 6—12 months ..	1	½	½	..	1	½	..	..	..	..
" 3— 6 months ..	½	..	..	..	1	½	..	6	2	6
" 1— 3 months ..	¼	..	..	..	½	¼	..	..	4	3
" up to 1 month ..	..	..	..	..	..	..	8	..	..	..

NOTE.—Gruel is made by cooking one pound of *ragi* flour mixed with 10 to 12 pounds of skim milk. Bajra may also be substituted for *ragi*.

Standard rations were later worked out specifically for the working bullocks and found suitable at several Agricultural Research Stations. They are given below :—

Rations for working bullocks.

Ration for	*I. Coconut cake.* lb.	oz.	*II. Cotton seed.* lb.	oz.	*III. Gingelly cake.* lb.	oz.	*IV. Groundnut cake.* lb.	oz.	*V. Horse-gram* lb.	oz.	*VI. Rice-bran.* lb.	oz.
(*a*) With paddy straw as roughage (Nitrogen—0·3 per cent).												
Maintenance ..	3	1	3	1	1	12	1	3	2	10	6	2
Heavy work ..	4	8	4	8	2	8	1	11	3	11	9	0
Very heavy work.	4	14	4	14	2	12	1	13	4	1	9	12
(*b*) With sorghum straw as roughage (Nitrogen—0·6 per cent).												
Maintenance ..	1	10	1	10	0	15	0	10	1	6	3	4
Heavy work ..	3	0	3	0	1	10	1	2	2	9	6	[illegible]
Very heavy work.	3	7	3	7	1	14	1	5	2	14	6	14

Six different rations have been given in the six columns, numbered I to VI. Any one of them would serve as the sole ration and supply the necessary amount of proteins for the animals

system. It is advisable to feed a mixture of two or three of the substances noted, at the rate of one half or one third of the quantities noted against them in the statement for best results. Thus with paddy straw as the roughage, animals doing heavy work require to be fed with either four lb. eight ounce of coconut cake, or one lb. and eleven ounce of groundnut cake or nine lb. of rice bran, but the better procedure would be not to feed any one of these by itself but to mix all the three, taking one-third of each, that is, one lb. eight ounce of coconut cake, nine ounce of groundnut cake and three lb. of rice bran and feed this mixture.

Miscellaneous feeding trials.—Cotton seed is used freely all over the State for feeding cattle, except in the city of Madras, where the milkmen hold that feeding milch cattle with cotton seeds tends to reduce the milk yields. A few tests conducted showed that this prejudice against cotton seeds is not based on actual facts and is without foundation.

Sweet lupin seeds were produced at the Potato Research Station, Nanjanad. It is rich in proteins, but contains a bitter alkaloid. The study of the material by the Research Officer, Medical College, Madras, showed that the quantity of bitter alkaloid present in lupin was not high enough to be toxic to cattle and induce injurious effects when fed in moderate quantities not exceeding three lb. a day per animal. The lupin seeds may be fed in a raw state either soaked in water, crushed or powdered or in any other suitable manner.

During 1944, experiments were conducted on feeding sorghum straw to work bullocks of the Central Farm, Coimbatore. The animals were of about the same size and age and they were given 15 lb. of straw each per day. The straw was fed whole and uncut to one group of animals; a second group was supplied with straw cut into one foot lengths with bill hooks and a third group received straw chaffed into bits two inches in length with a chaff cutter. There was less wastage of fodder when the straw was cut or chaffed as the animals did not pull down the straw from the manger and soil them to the same extent as with long straw. The actual quantity of fodder consumed by the animals was also more with cut and chaffed straw. These differences were statistically significant. Chaffing fodder may be said to be really advantageous and the following figures bear out the statement :—

Sorghum straw feeding results.

Treatment.	*Straw wasted per animal per day.*	*Wastage as percentage of straw fed.*	*Fodder consumed per animal per day.*	*Increased consumption of straw over long straw per day.*
	LB.	(= 15 LB.)	LB.	LB.
Long straw	3·5	23·3	11·2	..
Hand cut—one foot bits ..	2·9	19·3	12·1	0·9
Chaffed bits two inches long ..	1·7	11·5	13·2	2·0

In an experiment, chopped hay was fed after moistening with one-sixth the quantity of treacle and one-third the quantity of water, with dry untreated hay as the control. The group of animals receiving treacle consumed 0·3 lb. more hay per day than the controls and gained 0·6 lb. live weight, over a period of 12 weeks' trial. There was an indication in another test that molasses or treacle can successfully replace cereals in a fattening ration for pigs, up to one-third of the feed and promote appetite leading to increased intake of feed.

THE DAIRY INDUSTRY.

Milk production in the State.—Milk is highly valued as a good protective food by every body. It is of special value to the people of this country, who partake of a predominantly cereal diet deficient in proteins, fats, vitamins and mineral salts. Milk has all the essential ingredients of human food in a palatable and digestible form. The *per capita* consumption of milk is very low and the poorer sections of the people do not have any milk at all. Dairying is not an organized industry in the State. Milk production is a rural occupation and the bulk of the milk is produced and consumed in the villages themselves. The cultivators whose main occupation is agriculture, keep an animal or two partly to meet their own requirements and partly to supplement their meagre income by sale of ghee. In cities and around towns, a large number of professional milkmen maintain a few cows and buffaloes and eke out their livelihood, by selling the milk to the townsfolk. The animals kept for the production of milk are cows, buffaloes and goats. According to the livestock census of 1944, the number of milch cattle in the State was 5,029,513 cows, 2,919,614 buffaloes and 3,639,043 goats. There were 16 milch animals—cows and buffaloes only—for every 100 people in the State.

The milk yields of animals kept in different localities vary considerably. The milch cattle kept in urban areas which constitute approximately about 6 per cent of the milch cattle population of the State, are better than the village animals with regard to the production of milk. The daily average milk yield of cows and buffaloes kept in the Madras City has been estimated to be 8 lb. and 6 lb. respectively. The relatively high yield of the cows kept in the Madras City is attributed to the maintenance of cross-bred animals up to 25 per cent and Ongole animals up to 60 per cent of the milch stock. The cross-breds and the Ongoles are the best milch animals in the State. In other towns and the rural areas, the buffaloes are better milkers than cows and the estimate of their daily average milk yields are given below :—

	Cows (*in lb.*).	*Buffaloes* (*in lb.*).
Rural areas	2½	4
Urban areas	4	5

To assess the production of milk, data collected on lactation and dry periods of milch stock are given below together with the percentages of animals in dry and milk periods :—

Type of animal.	*Average lactation period (months).*	*Average dry period (months).*	*Percentage in milk.*	*Percentage in dry periods.*
Cows	7	8	47	53
Buffaloes	8	7	53	47
Goats	4	4½	47	53

Based on the above data, the annual production of milk in the State has been estimated at 568 lakhs of maunds, or 9 per cent of the total milk production in undivided India. This is made up of 274 lakhs of maunds of milk obtained from cows, 279 lakhs of maunds from buffaloes and 15 lakhs of maunds from goats.

The milk produced is estimated to be utilized in the following manner :—

—	*Quantity of milk in lakhs of maunds per year.*	*As percentages of total production.*
Consumed as milk	165·00	32·00
Made into ghee	267·00	52·00
Do. curd	77·00	15·00
Do. butter	3·00	0·60
Do. khoa	1·00	0·20
Do. ice cream ..	0·75	0·15
Do. cream	0·25	0·05
Total ..	514·00	100·0

The above figures emphasise the importance of ghee industry in the State. All the ghee produced is not consumed locally. Large quantities are exported to Bengal, Punjab, Mysore and Orissa. On an average the total annual export of ghee in the prewar period amounted to 112,598 maunds, valued at Rs. 47 lakhs.

THE COLLEGE DAIRY.

The Agricultural College Dairy, Coimbatore, was started in the year 1907, along with the college, for giving the students of the college practical training in dairying and demonstrating to the students and visitors improved methods of making and handling dairy products. A few Ongole and Kangayam cows and some buffaloes were kept and a suitable dairy building was put up and equipped during the next few years. Murrah baffaloes, Scindhi animals and cross-bred cows were added to the college herd gradually. The students were given instructions on the maintenance, housing and management of dairy animals, the production of clean milk and its conversion into various milk products like curd, separated milk, cream, butter, cheese, ghee and so forth. The dairy also supplied pure milk to the students and

the college staff, but this could never be done to the full requirements, due to the restricted facilities available. Investigation of problems connected with the management and feeding of cattle, the production of milk, etc., was also undertaken by the staff in a small way, during the course of their routine work. Some of the problems tackled in this manner are briefly reviewed below :—

Feeding experiments.—Feeding tests with cotton-seed cake showed that it could successfully replace cotton seed in the ration of milch animals. The studies could not be pursued further, as cotton seed cake was not readily and steadily available locally.

Feeding tobacco seed cake to dairy animals was found to be feasible. The animals did not relish the tobacco seed cake so well as groundnut cake. The tobacco seed cake was, however, noted to be harmless to the health of the cattle and it did not affect the milk yields adversely.

Malt refuse, a bye-product in the manufacture of malts, was much relished by cattle and its feeding tended to stimulate the flow of milk and increase the milk yield.

Ghee production.—The economics of local ghee production was studied in 1918–19. The manufacture of ghee and sale of ghee and the bye-product buttermilk was not economical and not so paying as the sale of fluid milk. The ghee produced in the villages was therefore adulterated in various ways and the value of the ghee was thereby lowered.

The local method of churning curd and making butter gave recovery of 6·7 per cent of butter against the recovery of 7·5 per cent by the use of the end-over-end churn used in creameries and dairies. While butter and ghee are made in fairly large quantities, it is advisable to use the end-over-end churn for butter making.

Standards have been laid for the purity of ghee and its grading. Grading is being done under the Agmark Scheme and the State marketing staff enforce the regulations in respect of the use of the Agmark seal by merchants and graders who have undertaken to grade and do business using the Agmark seal.

Bacterial in milk.—Milk is a nutritious substance and a favourable medium for the rapid growth and multiplication of bacteria that gain entrance into it. Bacteria may enter the milk through various sources. The milk teat canal of the cow itself is not free of bacteria and the milk freshly drawn from the cow even under the most sanitary conditions should not be expected to be free of bacteria. The milking shed, the vessels used in handling milk, the milker and the water used in the dairy for various purposes contribute their quota to the bacterial contamination of milk. Legal enactments in certain countries prohibit sale of milk not conforming to standards laid down for bacterial incidence in milk.

The milk produced in this country has generally a high bacterial population. The insanitary conditions under which milk is produced and the rapid multiplication of bacteria under the tropical climatic conditions are factors mainly responsible for this state of affairs. The temperature prevailing here for a large part of the year is about the optimum temperature for the growth and multiplication of bacteria. The bacterial population of milk goes on increasing as the milk is kept, the acidity of the milk increases, the milk gets sour and in course of time it gets curdled.

The observations made at the college dairy showed that the afternoon milk had a lower bacterial count than the mornings milk. Of the several factors responsible, the vessels used for handling milk were responsible for about 75 per cent of the bacterial contamination. Bacterial population of milk was highest during wet weather and the bacterial counts were more or less parallel to the atmospheric humidity—temperature ratio.

One of the suggestions often made for the improvement of the bacterial quality of the market milk is that milk should be pasteurised before it is offered for sale. It has, however, been noted at the Dairy Research Institute at Bangalore that pasteurisation of milk in this country is not so effective as in the Western countries. Some of the bacteria in milk in this country resist the temperature of pasteurisation and later multiply fast under the prevailing high temperature conditions, and it would therefore be seen that pasteurised milk is not any better, than unpasteurised milk. Pasteurisation is not effective and is therefore an unnecessary process that raises the cost of production of milk. It must also be remembered that people in the Western countries use pasteurised milk without further processing. Here in this country, on the other hand, milk is boiled by everybody before it is consumed, and so long as milk is boiled before use, its original bacterial population ceases to have much significance. Of the several methods of processing tried with a view to increase the keeping qualities of milk here, it was found that boiling the milk for ten minutes and keeping it covered was the best. Milk so treated keeps sweet for about ten hours. The processing method is also simple and does not require any investment or change in the local methods of handling milk. The only point that may be emphasised is that milk should be boiled properly for ten minutes before it is used for consumption..

Keeping qualities of milk in transport.—Studies were made about the methods of transporting milk from Bangalore to Madras, subjecting the milk initially and during transport to several treatments and using several types of containers. The milk reached Madras 17 hours after milking and none of the methods tried helped to keep the milk sufficiently sweet.

Plate 161.—*Poultry unit at A.R.S., Aduturai.* P. 1266

SHEEP BREEDING.

Bellary is one of the important centres of wool production in the State. The wocl produced is coarse and is mostly used for carpet making. The improvement of the Bellary sheep was preliminarily started at the Agricultural Research Station, Hagari, in 1912. The facilities for enlarging the original herd at Hagari were limited and a new station was started at Bantanhal specifically for the breeding of sheep in 1917. The Hagari flock was transferred to Bantanhal and enlarged by the purchase of some ewes. In course of time, it was seen that there was a high mortality of sheep at Bantanhal. The station was closed in 1922 and the sheep were transferred back to Hagari and later in 1925 to Hosur, where the improvement work was being continued. The sheep throve well at Hosur and the average wool clip that was 1 lb. 9 oz. at Hagari rose to two lb in 1926 and 2 lb and eleven ounces in 1932. The carcass also showed improvement, with a flattening of the back and a shortening of the legs.

The Bellary sheep are of mixed colours, with white and black predominating. The white wool is preferred by the trade and the manufacturing industries and fetch a higher price than black and other coloured wools in the market. When sheep breeding true to white were segregated in the beginning and mated together, the progeny produced were weak, unthrifty and subject to early mortality. White sheep with black face were, however, found to be as good as the general stock and whites with black face breeding true were attempted to be bred. It was, however, seen that sheep with mixed colours were really the hardiest and gave the heaviest woolclip. Finally the size of the woolclip determined the breeding policy rather than the colour of the wool. Two rams, Nos. 127 and 167, were selected for stud, as being prepotent and capable of increasing the woolclip of the herd. But still not much headway was made.

Grading-up of Bellary sheep with Bikanir rams has recently been taken up at Hosur. The Bikanir sheep are hardy, give an annual woolclip of seven pounds per head annually, thrive in all parts of India and are capable of resisting dry and droughty conditions of climate extremely well.

POULTRY.

Poultry improvement work had its beginning in 1868, when 'Brahmaputra' and 'Darking' fowls were obtained from Sydney, Australia, for trial at the Saidapet College Farm and for distribution to some people in the State. Brahmaputras were good egg layers and Darking hens were good mothers and both appeared to get along well under the tropical climatic conditions. The cocks were used for crossing the village hens, to improve and up-grade the village stock. The two breeds showed, however,

signs of deterioration in the course of seven or eight years and fresh stock were again obtained from Sydney, but this consignment was not satisfactory and poultry work at Saidapet was discontinued.

Different breeds of poultry imported from England, as well as local fowls, were maintained at the Agricultural College Dairy from 1914. The introduced birds were in general better egglayers and laid 120–180 eggs per year on the average and the local fowls laid about 90 eggs only. Of the several breeds tried, White Leghorns, Rhode Island Red and Light Sussex breeds fared well. These three breeds alone are popular with private individuals, though a few here and there maintain other exotic fancy breeds. White Leghorns have been noted to be the best egg layers. Rhode Island Reds are nearly as good as White Leghorns in egg production and are also heavy table birds. Some people prefer the Rhode Island Reds on account of their being dual purpose birds. The Light Sussex is also a dual purpose breed but the birds tend to get reduced in size, a few years after importation. If the size of the birds has to be maintained at the original level import of fresh breeding stock at periodic intervals has been found to be necessary.

The exotic breeds of fowls are very susceptible to infectious diseases and in the earlier years before protective vaccinations were developed, entire flocks of exotic breeds were wiped out by Raniket disease, Fowl Cholera and Fowl-pox. Local fowls were not so susceptible. It is advised to protect initially all the fowls against Raniket disease and take up protective vaccinations against the other two when there are epidemics in the locality.

A second poultry unit was opened at Hosur in 1927. The units at Coimbatore and Hosur have been from their inception regularly supplying eggs of the improved breeds of poultry, to people in the State for hatching purposes. The demand for eggs for hatching has always been heavy and consequently White Leghorns, Rhode Island Reds, and Light Sussex breeds have spread out widely in the State.

Poultry units were started in 1946 at the Agricultural Research Stations at Anakapalli, Samalkota, Palur, Koilpatti, Aduthurai, Coimbatore and Bapatla with the object of evolving a cross breed from the country hens and White Leghorns, combining the disease resistance of the country fowls and the good egg laying capacity of the Leghorns. Work is under way at all the stations and it is too early to say how far the crosses evolved would successfully combine the desirable characters of both the breeds.

CHAPTER 27.

SERICULTURE, APICULTURE, PISICULTURE AND LAC-CULTURE.

History of sericulture in India—The mulberry silk-worm and its life history—Economics of silk production—The eri silk-worm—Rearing and economics—*Beekeeping*—Domestication of the Indian Bee—Early attempts—General habits and life history of bees—Management of colonies—Pasturage—Appliances for extracting honey—Propaganda for apiculture as a side industry to agriculturists—*Pisiculture*—Kinds of fish culture—Studies in paddy fields at Aduthurai—Fish rearing experiments at Bapatla Agricultural College. *Lac culture*—The lac insect—Life history—Host plants tried—The 'palas' variety of lac.

SERICULTURE.

Introduction.—Larval forms of certain groups of insects have the peculiar habit of producing silk and constructing a protective casing round themselves just before they pupate. These are popularly known as cocoons. This habit is more pronounced in the case of moths. One or two species have developed this habit to such a degree of perfection that man has not hesitated to exploit them for his personal benefit. The silk in popular use is a product of the salivary glands of the silk-worms. It occurs in the form of a transparent gummy secretion which dries up on coming into contact with air. The worms rapidly spin this material into fine threads as it exudes from the glands and later weave it round themselves before pupation.

The economic possibilities of silk worm rearing have been realised in China from the remote times and the industry has been so popular in that country that it has served as the main source of the world supply. It appears to have subsequently spread to India and the use of the product as a fine article of dress came into vogue along with the advancement of civilization. More recently the fabric has been extensively used for the manufacture of parachutes during World War II. Minor uses of silk consist of adapting the silk gut in surgical operations and occasionally as an equipment for attaching the hooks in the sport of angling.

In India, sericulture has been a thriving cottage industry in parts of Kashmir, Bengal, Bihar, Mysore and Madras from the early days. It is roughly estimated that about three to four million persons earn their livelihood through silk-worm rearing while the value of the silk produced annually amounts to several crores of rupees. In Madras, the industry was first fostered by the Agricultural Department, but was later transferred to the Industries Department by about 1922.

The families of moths, viz., *Bombycidae and Saturnidae* are concerned in silk production. The Mulberry silk-worm (*Bombyx*) *mori*) comes under the first category. The other species, viz., *Attacus ricini*, (the Eri Silk-worm) and *Antheroea paphia* and *A. assama* (Tassar and Muga silk-worms) come under the family *Saturnidae*.

The Mulberry silk-worm, B. mori (*Bombycidae*).—The species is exclusively reared on mulberry leaves and is perhaps the most popular and remunerative. What little is being done in South India in the line is on the Mysore plateau, as the mild and salubrious climate is congenial for the cultivation of the mulberry crop and for the development of the worms. The rearing of the worms is also practised in the Kollegal taluk which is contiguous with the Mysore plateau. The special feature of this species is that the cocoons are spun in one continuous thread which can be reeled off easily. The continuity is broken if the imago is allowed to escape and as such the pupae have necessarily to be killed before the silk is reeled. The worms have been under domestication for a very long time and the moths are practically incapable of flight. Two varieties, viz., the univoltine, passing through only one brood in a year and the polyvoltine having a number of broods, exist and it is only the latter which is popular in South India. The moth is creamy white in colour and completes its life cycle in the course of six to eight weeks. The female lays a number of whitish seed-like eggs and the young caterpillars hatch out within ten days. The full fed caterpillar is two inches long, pale white in colour with a dorsal ' horn ' on the anal segment. Caterpillars nearing pupation are picked out and distributed in a special contrivance called ' Chandrakhi ', wherein they select convenient spots to spin their yellowish white cocoons and pupate. The adult emerges in 10–12 days. These cocoons are taken out and stifled to kill the pupae inside. The details of tending these worms form a special technique and it is carried on with the help of a few simple equipments. One of the special features is that the leaves have to be minced into very fine strips for being fed to the young larvae, while they can be given in larger strips with the development and growth of the worms.

Economics.—An ounce of the seed may give about 40,000 worms and this is about the number which a man and a juvenile can manage. Twenty-five to thirty-five maunds of leaves are required to rear this number. This stock may give about five and a half lb. of raw silk and two lb. of waste. The raw silk is then subjected to a series of highly technical processes before it gets the much prized lustre. The margin of profit was about Rs. 50-60 during the pre-war days and hence not quite attractive, but with the present inflated prices, especially for the genuine stuff, the prospects look much better.

Diseases.—These worms are exceedingly delicate and are subject to one or two fatal diseases. The more destructive malady

is '*Pebrine*' and the disease is both hereditary as well as contagious. It is caused by a protozoan parasite. The affected caterpillars turn pale brownish and die off in numbers. The disease can be controlled by the selection of disease-free eggs for rearing. Other diseases like *Flacherie*, *Grasserie*, etc., are of minor importance and can be warded off by adhering to the elementary principles of sanitation.

The Eri silk-worm—Attacus ricini.—Among the three species mentioned under Saturnidae, the Eri silk-worm commands a certain amount of popularity in the South. These worms can be profitably reared only on leaves of castor though they have been observed to feed on a few other hosts as well. The special feature about this species is that the cocoons consist of separate strands of silk which have to be carded and spun and there is, therefore, no harm in allowing the moths to escape. This worm is a native of Assam and its rearing is also practised in parts of Bengal, Nepal, Kashmir, etc. The egg stage lasts for seven to nine days, the larval 17–25 days and the pupal 17–18 days, the total life-cycle extending to 41–52 days. These worms are fairly hardy and easy to rear and are not susceptible to any of the serious diseases.

The moths are allowed to escape and the empty cocoons are first reversed with a special machine to remove the pupal cases. They are then cleaned and boiled in water for about 45 minutes with a little washing soda. The material is later dried, carded and spun.

Economics.—It is estimated that about ¼ ounce of the eggs giving rise to 4,000 caterpillars would be the convenient limit for a ryot. About 30 cents of land under castor may be required for the leaf supply. It has also to be mentioned here that the steady removal of the leaves would decrease the yield from the crop. These worms may give about two and a half lb. of silk, but the produce, being somewhat coarse, does not find a ready market.

The rearing of Eri silk-worms was tried at Coimbatore first in the year 1932. Eight broods were reared during the year 1932–33 and the bionomics of the worm and the economics of rearing them studied. Several members of the district staff were trained in the subject at Samalkota and Madras and were posted to the Agricultural Research Stations with a view to popularise the industry. The response from the public has not been sufficiently encouraging on account of the difficulty in marketing the produce and the interest in the subject therefore waned out very soon.

BEE KEEPING.

Honey has been an article of household use in India from time immemorial either as a food or as medicine. Bulk of the supply was from the Rock bee—*Apis dorsata* which occurs mostly in the forest areas. The jungle tribes are the only adepts in the art

of collecting the produce but the liquid available can hardly be called honey on account of the extremely imperfect and unhygienic methods of extraction and preservation. The domestication of the honeybee and the possibilities of extracting honey in its purest form were practically unknown till about three or four decades ago. Crude methods of rearing the Indian bee—*Apis indica* have been in vogue and are extant even to-day in parts of Coorg, Mysore, Northern Circars, etc. Empty earthen pots are smeared with a little wax inside and kept in convenient and well-protected places like shady corners, forks of trees, etc., in the jungles during the swarming season. These receptacles get tenanted by stray swarms of bees in due course. The pots are then removed during nights to the residence of the villagers and left alone until the honey season. A certain amount of ingenuity is also exhibited by placing one or two smaller pots over the first one, the additional receptacles providing extra accommodation and facilities for storing honey. After an appreciable quantity of honey has been gathered and stored by the bees, the pots are gently tilted and the bees smoked out. The honey-combs are then removed one by one and their contents squeezed out with hands. These methods are crude and wasteful because of the enormous destruction of life; and the produce itself gets fermented and unpalatable on account of the unhygienic conditions.

The earliest attempts to domesticate the Indian bee appear to have been made by the Jesuit Fathers at Tiruchirappalli and Shembaganur, by about the beginning of this century. Small wooden hives were designed and swarms housed in them. Appreciable quantities of honey are reported to have been extracted. The findings of these enthusiasts published in the form of a paper in the Agricultural Journal of India by about 1916 was a real eye-opener regarding the possibilities of this cottage industry. But there was little or no response from the public until about 1925 when the Y.M.C.A. authorities at Ramanathapuram, Marthandam, etc., took up the popularisation of this industry, as one of the items of rural reconstruction. The phenomenal depression which set in by 1930 made it imperative on the part of the Government to devise ways and means for providing some occupation for the ryots during the slack season and thus augment their scanty income from the land. Beekeeping along with similar side industries like poultry rearing, kitchen gardening, silk-worm rearing, etc., was considered as one of the possible lines for development. As there was very little on record on the fundamental and economic aspects of the Indian bee, detailed research was initiated for the first time under the Government Entomologist by 1931. Attention was concentrated on the different aspects and the following is a short resume of the results obtained so far.

General habits of bees—Life history of different members.—In the case of a social insect like the honey bee, the fertilized queen is the only member of the colony capable of reproducing the species;

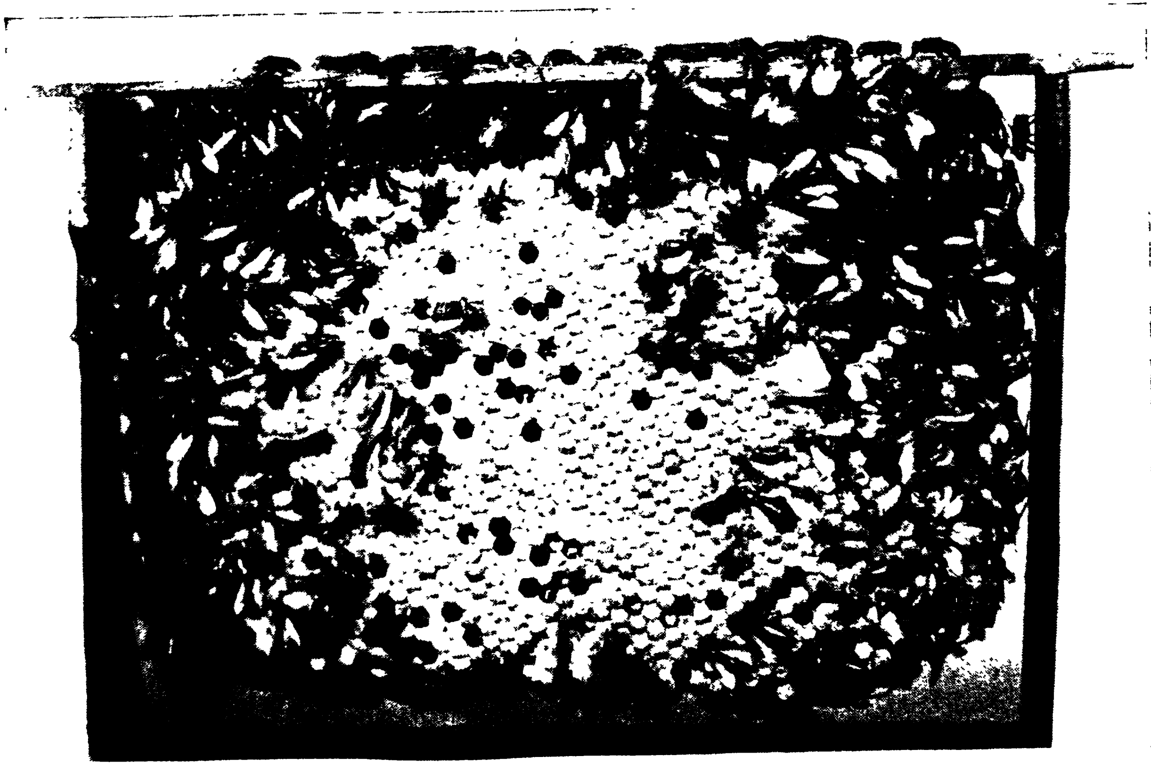

Plate 162.—Worker Brood of A. indica.

P. 1273

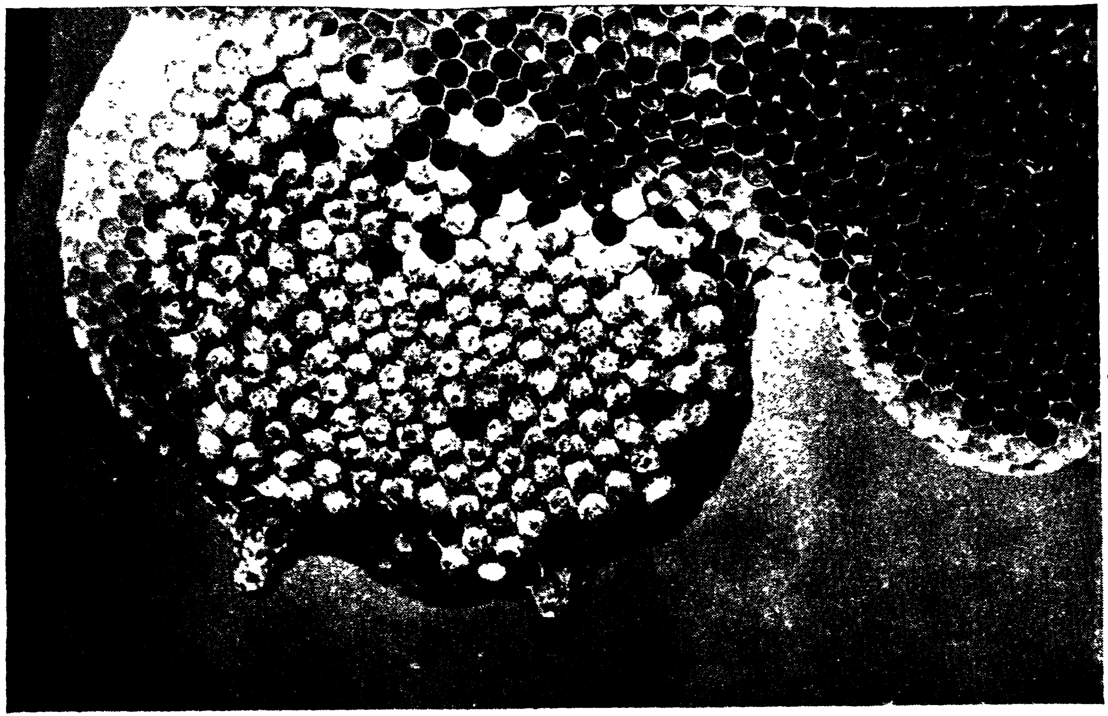

Plate 163.—*Drone Brood and Queen Cells.*

P. 1274

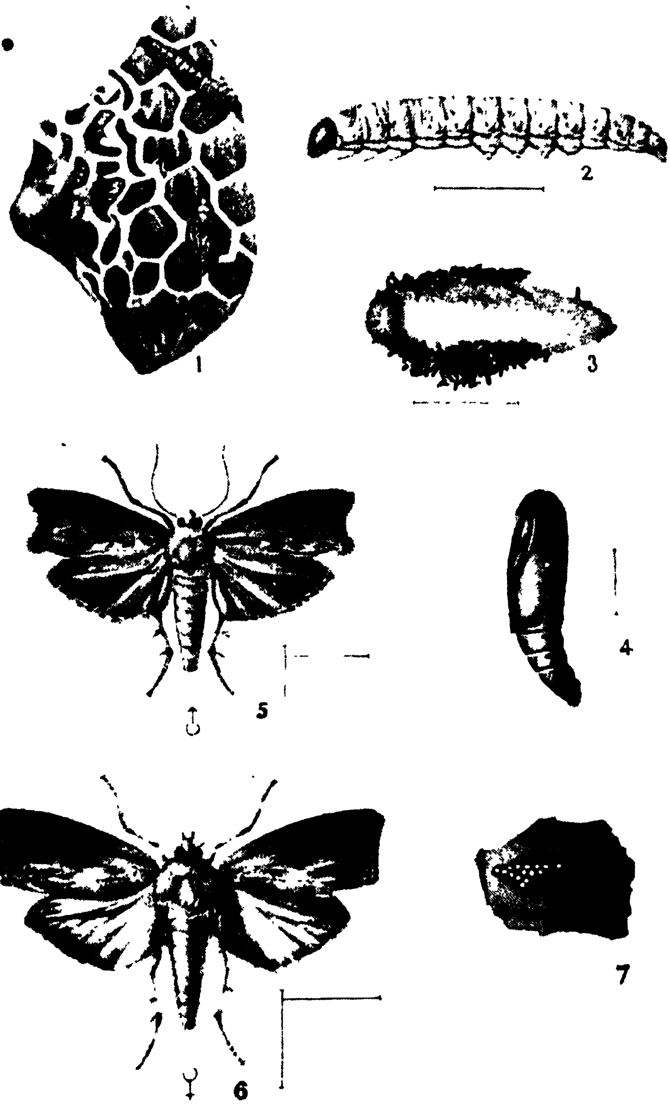

Plate 164.—*The wax moth—Different stages.* P. 1275

About 39 worker cells go for a square inch and the queen lays an egg in each cell. These eggs hatch out into tiny helpless grubs in three days. They are fed and looked after by the nurse bees for about four days when they get full grown. The cells are then sealed with wax and the grubs pupate inside. The pupal period lasts for about 12 days after which the bee emerges. The drone grubs are reared in slightly bigger cells (36 in a square inch) and their life history is more or less similar to that of the worker except for the fact that the period is longer by a day or two and that the sealing of the cells is a little convex with a small hole at the centre. Queens are reared in separate cells constructed along the lower border of the brood combs. The grubs are nurtured with special care and the total life history extends to about 16 days. The longevity of the workers ranges from 45 to 80 days during the brisk foraging season and the span is longer during the slack periods. The drones live up to about 60 days. The normal life of the queens is about three years and their average daily rate of egg laying has been computed to be about 500 during favourable seasons. The approximate population of a bee colony in thriving condition is likely to be over 32,000, half of which are foragers and the other half the nurse bees which remain inside the hive and attend to indoor activities. The worker brood area may extend to about 275 square inches, i.e., over 10,000 cells. Counts of the foragers in a prosperous colony go to show that the bees perform about 5,580 trips for pollen and about 19,000 trips for nectar in the course of a day. The maximum distance to which a bee is capable of flying in search of food is a little over a mile but the effective range is limited to a furlong or two. (Plates 182 and 183.)

Bees respond to the climatic and weather factors to a remarkable degree. High foraging activity is exhibited during the morning between 8 and 10 a.m. when the temperature ranges from 76 degrees to 80 degrees F and the humidity from 71 to 80 per cent. Brisk work is also evinced immediately after a sharp shower. Strong winds, high temperatures, cloudy and drizzling weather are detrimental to the outdoor activities. Bees were also found to exert appreciable discrimination in visiting their pasturage plants, the preference being to sources from which they were able to collect large quantities of their food materials at a time. The time of visit also is adjusted according to the period when the flowers open. It was also found that the Indian bee is capable of bearing food loads weighing up to about 35 per cent of its body weight and this performance compares favourably with the capacity of the foreign bees.

Management.—An intimate knowledge of the domestic economy of the bees was gathered so as to enable the bee-keeper to gauge their requirement and maintain them in a prosperous condition. A special technique was evolved for the initial procurement of

colonies from their natural haunts, their aftercare and the subsequent building up of their strength for honey gathering. Simple methods for manipulations like dividing, uniting, queen rearing, queen introduction, artificial feeding, etc., were adapted to suit the local conditions. Greater attention was devoted towards the solution of the problem of swarm control. The time honoured method was the periodical removal of the queen cells but the process was crude and far from perfect. Further attempts were made to improve the technique and the most promising lines are: (i) allowing the first swarm to issue and preventing further ones; (ii) periodical removal of brood combs to provide more egg laying space; (iii) improvised artificial division with the object of causing a temporary cessation of egg-laying and an automatic requeening of the original colony and (iv) interchange of the positions of hives to distribute the bee population, etc. All these methods showed various degrees of promise and the work is being continued to assess their relative merits and devise new ones, if possible. Interesting information has also been gathered on the breeding and foraging activities during the different seasons, the ratio of the field bees and nurse bees and the consequent influence on the progress of the colony and the development of the swarming impulse, etc.

Pasturage.—Considerable attention was also bestowed on this aspect and a comprehensive list of the bee pasturage plants of the State has been prepared along with their approximate months of flowering. The more important sources of pollen are graminaceous plants like sorghum, bajra, maize, etc., and trees like *Holoptelea integrifolia*, *Borasses flabillifer*, *Ailanthus excelsa* and *Pithecolobium dulce*, *Peltophorum*. etc. Nectar is freely collected from cotton, tamarind, margosa, etc. Samples of honey from different sources were analysed chemically and were found to compare favourably with the foreign material. A special process of ripening honey, i.e., keeping the container with the honey in a water bath under a steady temperature of 60° C for about half an hour and subsequently storing it in air-tight receptacles was found to prevent deterioration. Some work was also done on the granulation of honey. Samples were forced to granulate quickly by subjecting them to low and normal temperatures on alternate days. It was also found possible to improve the consistency of these samples by exposing them to a high pressure under vacuum and dessication with sulphuric acid.

Bee enemies.—This is another aspect which received concentrated attention. Special mention must be made about the evolution of a few simple manipulations towards the control of the wax moth—*Galleria mellonella F*. which is the most serious pest of honey bees all the world over. (Plate 184.) Mechanical destruction of the egg masses, minimising the chances of oviposition on the hives by frequently changing the hive bodies and the elimination of the caterpillars from stored combs by exposure to a

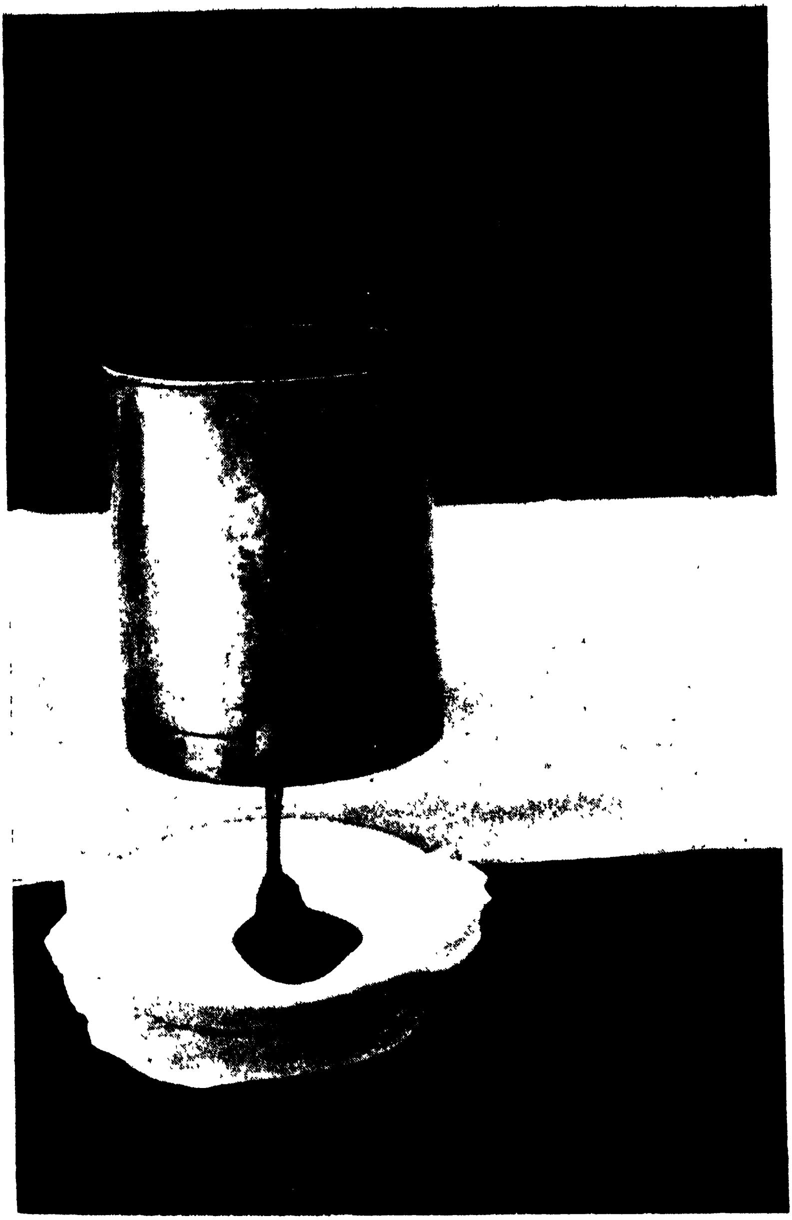

Plate 165.—*Honey extractor.* P. 1279

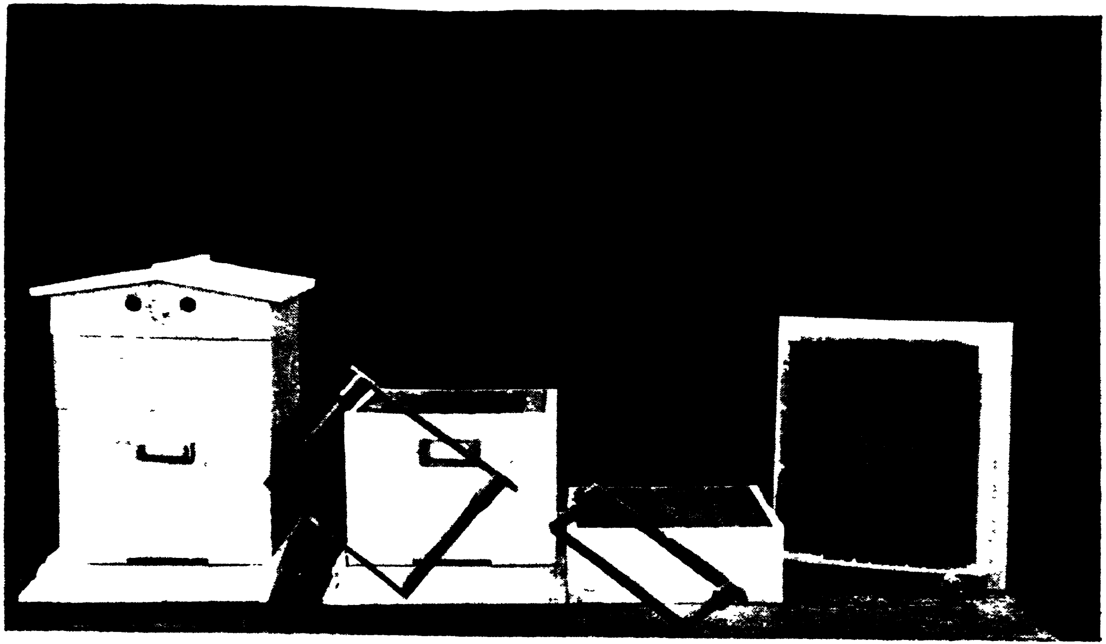

Plate 166.—Bee hive and its parts.

P. 1280

mild sun for a short time constitute the main lines of control. Attempts to drive out caterpillars from the combs with the help of artificial heat and light have also given indicative results. These methods are entirely original and have definitely solved this problem. Equally simple measures were evolved to control other bee enemies like the black ant—*Camponotus compressus H*, the smaller bee-hunter wasp—*Palarus orientalis K*, etc.

Appliances.—Cheap and efficient patterns of extractors (Plate 185) were devised on the principle of the foreign models. Minor appliances like drone and queen traps, queen excluders, bee escapers, swarm traps, etc., were either devised or adapted. A comb foundation mill designed to prepare sheets suitable to the size of the cells of *Apis indica* was specially ordered for and imported from America by 1939. The machine has since been serving quite a useful purpose and has met heavy demands from all over the State as well as from outside.

Propaganda.—Advice and help were rendered to interested parties either in person or by correspondence. A few temporary schemes with a modest staff of one or two fieldmen and a few maistries were in force in some of the favourable localities like Chittoor, Visakhapatnam, Godavari, etc. Short courses on bee-keeping extending for about a fortnight were held for the benefit of the interested parties during February from 1935 onwards till 1948. Departmental officers as well as amateurs were trained as and when necessity occurred. Appicultural exhibits invariably form an attractive feature in most of the important exhibitions. To give a further impetus to the spread of this industry, annual 'Honey weeks' were organized from the year 1937 to 1945 and celebrated all over the State. The section also undertakes to supply standard apicultural requisites to interested parties at reasonable rates. Free pamphlets and priced publications on the practical aspects of the subject are also made available to the public.

As a result of the continued endeavours, almost the last word has been said on the practical aspects of rearing the Indian bee under the existing conditions. This cottage industry has now taken a firm root as an interesting and paying proposition and the response from the public has been highly encouraging. Only about 1,000 hives were reported to have been maintained in this State by 1934. From this modest beginning, the number has gone on steadily appreciating by about 1,000 a year, until a maximum of over 10,000 was reached by 1944. (Plate 186.) With the food problem looming large as an aftermath of the Second World War, a perceptible decline in the interest was evident in 1945 and this is probably due to the activities of the department being concentrated on the solution of the more important problem of food production. But with the return of normal conditions, there is

plenty of evidence for the renewed interest in the subject. A gist of the progressive census of the hives in the State from 1936 to 1946 and the largest figures is furnished below :—

Year.	*Total number of hives.*	*Year.*	*Total number of hives.*
1936	1,008	1942	8,749
1937	1,754	1943	10,265
1938	2,892	1944	10,173
1939	4,323	1945	9,088
1940	5,999	1946	6,850
1941	7,530		

Total number of bee-hives in the Madras State, **1946.**

Number and name of district.	*Number of hives.*
North Region.	
1 North Visakhapatnam	303
2 South Visakhapatnam	63
3 East Godavari	1,373
4 West Godavari	494
5 Krishna	15
6 Guntur	47
7 Kurnool	3
8 Cuddapah	Nil.
9 Bellary	4
10 Ananthapur	Nil.
11 Chingleput	143
12 Chittoor	292
13 Nellore	36
South Region.	
14 South Arcot	51
15 Tanjore	610
16 Tiruchirappalli	100
17 Madurai	776
18 Tirunelveli	838
19 Ramanathapuram	183
20 Salem	141
21 North Arcot	41
22 Coimbatore	394
23 Nilgiris	157
24 Malabar	257
25 South Kanara	529
Total	6,850

Rock bee (Apis dorsata).—Some work was also done on this species. This bee occurs generally in the hilly sub-mountainous regions and is capable of storing large quantities of honey and in fact it is a source of income to the Madras Forest Department, under minor forest produce. These bees have a peculiar habit of constructing their single combs in inaccessible places and storing honey and rearing brood in the same comb. They are easily irritable and do not, as a rule, brook human handling, not to speak of their confirmed migratory habits. Domestication of this species was, therefore, out of question and attention was devoted towards the evolution of better methods of extraction and preservation of the honey. After experimenting with a number of

devices, two patterns of honey extractors and a honey strainer were finally designed for extracting the honey without any contamination. The quintessence of success in the preservation of the material was by ripening it over a water bath at a temperature of 60° C. and storing it in clean and airtight receptacles. These processes have practically revolutionised the previous methods, and the samples thus treated were found to keep on without fermenting for indefinite periods.

Some work was also done on the extraction of wax and it was found that this valuable material constitutes about 25 per cent of the gross weight of the combs.

PISCICULTURE.

Pisiculture or fish culture is the intensive cultivation of fishes. In India, fish culture has been practised in Bengal, Bihar and Orissa and to some extent in Travancore. For want of sufficient scientific knowledge and enterprise on the part of the people the profitable water sources in and around many ponds are allowed to lie waste without proper utilization. Fish culture is a potenfial and profitable industry and given the proper backing would prove to be of great economic importance to the country and a source of profit to the individual practising it. Attempts may be made to utilize every source of water available for growing fish. It is said that an acre of water space when properly farmed would yield better returns than an acre of cultivated land.

Kinds of fish culture.—Fish culture can be divided into three kinds. (1) Marine, (2) Estuarine and (3) Fresh water. In inlands only fresh water culture of fishes is possible. Fresh water culture can be again divided into (i) Riverine (Growing fishes in rivers), (ii) Lakerine (in lakes), (iii) Pond culture in (ponds) and (iv) Paddy-cum-fish culture (cultivating fish in rice fields). Riverine and lakerine cultures presuppose a co-operative effort in utilizing common sources of water. By individual efforts only pond culture and paddy-cum-fish culture are possible and they can be easily taken up by interested persons.

Fish rearing in paddy fields—In the Agricultural Research Station, Aduthurai, Tanjore district.—There are over a million acres of wet land of very flat nature in the Cauvery delta which are under swamp rice crops from June to January every year.

The irrigation sources are the Cauvery river and its numerous distributories. Water from the river is conveyed through the main channels from which branch channels or field channels take off and deliver the water direct into the rice fields. With the construction of the Mettur Reservoir, the supply has been so well regulated that there is hardly any dearth of supply at any time during the irrigation season now. With such assured water-supply for eight months in the year, trials relating to the rearing of fish

in rice fields were started in 1933–34 paddy season. As indigenous varieties of fish including many species of carps naturally occur in the river water, artificial rearing of the fry was not attempted but precautions were taken to see that fish once entered the block of land selected for the experiment were not allowed to escape by the provision at the drainage vents of 'V' shaped bamboo screens which allowed entry of the fish into the rice field but not their escape through them. The vent through which irrigated water was allowed to enter the block of land was completely screened off by wire netting with close meshes. The provision of 'V' shaped screen was made at the drainage vent purposely to take advantage of the natural tendency of all fishes to swim against the current. Streams of fish could be seen forcing their way through the narrow slit in the 'V' shaped screen against the flowing water. The block of land selected was about 12 acres in extent with two parallel rows of fields, 14 in each row with a long common bund dividing the two rows of plots. The length of this common bund was nearly 1,500 feet running west to east. These fields were planted to two crops of rice during the season of eight months, the first crop occupying the ground from June to end of September and second crop from October to the end of January or middle of February. The fishes on entering were at perfect liberty to move about in all the fields of the experimental plot. But it was soon realized that conditions became unsuitable for fish to thrive when the fields were ploughed or when water went down in depth (below two inches) in the fields. Young fish particularly carps were also noticed to die in large numbers when temperature of the water in the fields rose beyond 36° C. Such high temperature prevails on almost all days from June to middle of September during the hours 12 noon to 3 p.m. in the afternoon in the unplanted fields in the delta. Within 20 days after planting a rice crop, the shade produced by the rapidly tillering rice plants was sufficient to prevent the rise of temperature of water in the fields and to protect the young fish from heat stroke. To save the fish from ill effects of the above conditions, a central trench of two feet in width and two feet in depth was dug in the place of the central long bund. The trench was in turn connected to a six feet wide and eight feet deep trench of about 25 feet length at the head of the block of land to which water was let in for irrigating the whole block.

At the end of the rice season in January the water-supply is cut off from Mettur in consequence of which the rivers, channels and fields dry up with the result that the fish either perish or are caught by the people and eaten irrespective, of their size and weight. A certain number, of course, escape into the numerous village tanks scattered all over the delta but a large proportion of the young and small fish generally perishes. The big trench at the head of the experimental block served to give shelter to the fish and carry them over to the next irrigation season through the dry months February to May. The trench was subsequently

widened and deepened into a fish pond occupying about seven cents in area; and 300 to 400 lb. of mature fish are caught and sold annually through the long central trench was filled up and the experiment of rearing fish in the rice fields discontinued after three seasons in 1936.

Not only carp but other fishes mostly predatious in nature also get into the fields and finally into the fish pond when fish are allowed free entry into the fields from the rivers and channels. If carp alone are to be reared, artificial rearing of the carp fry will have to be undertaken during the irrigation season to the exclusion of all other kinds.

Ophiocephalus striatatus and *Ophiocephalus punctalus* were found to breed freely in rice fields from the months of September to November. About 10,000 eggs are laid in a circular raft made by sticking together cut leaves of rice and grasses. The young of *Ophiocephalus striatatus* are blood red in colour and when the young fry move in water the tails look bloody. Three thousand to four thousand young ones are noted in one brood. Of the carps, *Labeo fimbiatus* attains the biggest size. A full-grown specimen would weigh a pound while others vary in weight from three to eight oz. when full grown. None of these carps attain their full size within the eight months of the paddy season as none of them gave more than four oz. in fish weight during the time. So it is essential that the immature fish should be carried over through the summer to the second season in a fish pond in paddy fields if the maximum size or weight of the fish is to be obtained.

A fresh fish pond was dug on the station and stocked with *Gourami* fingerlings in April 1940. These were fed on groundnut cake and when specimens were caught at the end of two years, many of them had attained five pounds in weight. The fish spawned freely in the pond which is eight feet in depth and more than 500 young fry were got.

Statement showing yearly catches of fish from a seven cent fish pond on the Agricultural Research Station, Aduthurai.

Years.	LB.	OZ.	*Years.*	LB.	OZ.
1936–37	376	0	1942–43	323	10
1937–38	441	10	1943–44	350	1
1938–39	235	15	1944–45	329	1
1939–40	98	14	1945–46	123	2
1940–41	419	12	1946–47	237	10
1941–42	210	3			

An average harvest of 50 lb. of fish from an acre will indeed represent a great addition to the supply of food in the country, particularly so, when it is first-class animal protein.

Work done in Bapatla Agricultural College and Veeravaram Farm in fish rearing.—Fish culture was practised at the Bapatla Agricultural College on a small scale for three seasons during 1946 to 1949. A low-lying patch of water converted into a small

pond 100 feet by 100 feet in area in 1946 to serve as a source of water to cattle and to the newly planted estate plantations, was expected to prove useful for rearing fish also.

As a first trial 300 *catla* fingerlings were charged in the pond in the second week of November 1946. Water weeds like *Chara* and *Vallisneria* were put in subsequently to serve as food for the growing fishes and these established themselves well in the tank within a short time. The slopes of the tank were planted with *Cannas* and other green plants for appearance and shade. Grass growth became thick at the edges of water and afforded shelter and shade for the fishes. In January 1947, 23 *Gourami* and 100 *Etroplus* (salt water perch) were let in as varieties that would breed in confined water, since *Catla* which is riverine in habit does not breed in stagnant water though it grows well. The fishes showed satisfactory growth within a short time and *Catla* attained a marketable size within three months. In the first year out of the 300 charged a total number of 277 fish were recovered working to a percentage of 92. A revenue of Rs. 53–7–0 was realised with a profit of Rs. 30–3–0 over the expenditure of Rs. 23–4–0. With the encouraging results obtained in 1946 the pond was charged during the next season with 600 *Catla* fingerlings in August and 22 *Gourami* and 120 *Etroplus* in September 1947. Manuring with ammonium sulphate and superphosphate was also done to promote the growth of *algæ*. The growth was not so uniform as in 1946. An intensely severe summer was perhaps responsible for the poorer catch, the profit being only about Rs. 20 during the season, with a catch of 64·7 per cent on the total charged as against 98 per cent in 1946. In the 1948–49 season again the profits and the catch were Rs. 17 and 65 per cent respectively.

During the three seasons, several records were maintained like periodical depths of water, the temperature at different depths, size of fish caught and so on. It was seen that with a small pond like that in Bapatla area a subsidiary income could be realised from pisciculture without much trouble. Of the varieties tried, *Catla* was the most promising and curiously enough in no season was any *Etroplus* recovered in the catch; evidently conditions are not favourable for their development.

Paddy-*cum*-fish culture was attempted during two seasons in 1948–49. Due to unsuitable conditions such as inundation of the fields resulting in over-flow of the water during the rainy months and sudden shortage of water in the supply channel during the dry periods, paddy-*cum*-fish culture was not a success in these areas.

LAC-CULTURE.

The Lac industry which is a prosperous Indian monopoly has not found entry into South India perhaps due to the absence of suitable plants to serve as hosts and of favourable weather conditions for the insects all round the year.

Tachardia lacca, the lac insect is a species of scale insect which is propagated on certain trees. The resinous encrustation produced by this insect form the lac (*Araku*) of commerce. A deep red dye is also obtained from these insects which is largely used in colouring silk. The insect naturally infects several trees and is also propagated on *Butea frondosa*, *Zizyphus jujuba* and *Acacia arabica* with considerable success in Mysore and Upper India.

The insects on swarming, establish themselves on the twigs under favourable conditions. The female insects grow in size and exude the resinous lac which develops into an encrustation in the course of two and a half months. The dye is present in the form of a red liquid in the mother.

The grain lac (original form on the trees) is collected and the dye and lac are extracted from it.

Experiments on lac breeding conducted at Coimbatore in 1911–12 had shown that lac insects can be established more successfully on *Zizyphus* than on *Acacia arabica*.

Investigations, relating to the possibility of lac cultivation on the common trees growing in South India, were undertaken at the Bapatla Agricultural College, and trials were carried out. Of the two varieties of lac ' *Kusum* ' and ' *Palas* ' it was considered that ' Kusum ' would be more suitable for breeding under South Indian conditions owing to its wider host range. The trials were carried out during the months December to February when the weather is cool and dry, as heavy rains or excessive heat are not favourable for lac cultivation.

A number of trees were inoculated with 25 seers of Kusum brood lac obtained from the Director, Indian Lac Research Institute, Nankum (Bihar), during 1947–48. As many as 20 different common trees were inoculated by the longitudinal and the lateral methods and the growth observed. The following trees were inoculated :—(1) Mango. (2) Kapok. (3) Tamarind. (4) Ber (*Zizyphus jujuba*). (5) *Acacia arabica*. (6) *Albezzia lebbak*. (7) *Cryptostegia grandiflora*. (8) Sapota. (9) Castor. (10) Jatropha. (11) Banyan. (12) *Ficus tsiela*. (13) Pomegranate. (14) *Ficus religiosa*. (15) *Eugenia jambolana*. (16) *Glyricidia maculata*. (17) Indian almond (*Terminalia catappa*). (18) Neem. (19) Mulberry. (20) Agathi (*Sesbania grandiflora*). (21) *Pithecolobium dulce*. (22) *Delonix regia*.

Of the hosts tried the lac established well on *Ficus bengalensis*, *Ficus tsiela*, *Acacia arabica*, Kapok, *Ficus religiosa*, ' Agathi ' *Pithecolobium dulce* and Gold mohur (*Delonix regia*). In the case of Kapok and Gold mohur, even though the lac established on the branches, the growth was cut short when the leaves were shed by the trees, thus affording little protection from the direct rays of the sun. The most promising hosts proved to be *Acacia arabica*, *Ficus bengalensis* and *Ficus tsiela*.

Cultivation of '*Palas*' variety of lac on 'Ber' (*Zizyphus*) trees was tried at Agricultural Research Station, Guntur. The second crop season of October–January was selected, and inoculation was done in September to avoid the north-east monsoon in the early stages. Four trees were selected for the trial and was given a heavy pruning in July 1948. Brood lac was inoculated and removed after three weeks when most of the nymphs had spread on to the host. The lac was collected in July 1949 and the total yield was 11 lb. from the three trees, the other being left over for self inoculation. Self inoculation did not prove a success as the total yield was low and lac of the previous years dried up and partly shed.

'*Palas*' brood lac was once again inoculated in October 1949 and harvested in May 1950, on the trees from which lac was removed. No regular pruning was done but the removal of lac involved a light pruning. Due to various reasons such as adverse climate, abundance of predator *Eublemma amabilis*, and perhaps lack of heavy pruning, the crop was a failure.

Further studies on lac cultivation are being continued.

CHAPTER 28.

AGRICULTURAL ENGINEERING.

The beginnings of research in agricultural engineering—Introduction of implements from abroad—Modifications to local conditions —Improvements in the plough, the harrow, the Guntaka—Implements for wet land cropping, the puddler, the manure trampler—Dry farming implements, the bundformer, the buckscraper, the lister cultivators and seed drills.

Machines.—**Trials with imported machines—The thrashing, winnowing and harvesting machines—Chaff cutters—Rice shellers—sugarcane mills and improvements—Seed testers—Presses—Graders of agricultural produce like oranges, potatoes—Turmeric polisher—Hand gins for cotton—Arecanut dehuskers—Sprayers—Irrigation devices—Water-lifts—Wind-mills—Roll easy mhote wheel—Experiments with different kinds of water-lifts and results obtained—Bullock carts, improvement in design, draft, harness and yoke—Studies with vegetable oils as fuel—Tractors, pump-sets and extension service activities—Workshop at Coimbatore and Bapatla.**

From early times when man turned from his nomadic life and pastoral pursuits to a settled agricultural life, he has been attempting to reduce the manual labour required for preparing the land, sowing, intercultivation, harvesting, thrashing and so forth, by using bullock and horse power. These in turn are being substituted today in an increasing manner by heat engines and electric motors. At every stage is seen a progressive efficiency in the use of power and development in the design of machinery and Agricultural Engineering plays a great part in the successful management of the agricultural industry.

A few ploughs and implements of various types produced in England and America were obtained now and then by the early workers for use at the Agricultural College, Coimbatore and the several Agricultural Stations in the State. Many of them were not suitable and some were beyond the capacity of the ordinary cultivators. They had to be suitably modified to suit the conditions prevailing here. Thus commenced Agricultural Engineering Research, without a definite plan or goal. The Royal Commission of Agriculture that visited India in 1928 recommended that Agricultural Engineering Research should be undertaken as one of the means of improving agricultural efficiency. A research wing for Agricultural Engineering was formed at the Agricultural Research Institute at Coimbatore with a small staff and a workshop. Research on the outstanding Agricultural Engineering problems was taken on hand. It was realized from the beginning that agricultural machinery developed for use in this country

should be cheap and within the means of the ordinary cultivators, that they should be simple in design and construction, should lend themselves to repair by the village smiths and that they should economise labour. All these conditions are satisfied by the indigenous implements and their design are a marvel to the Western engineers, who attempted to effect improvements in the original models, without much success. The testing and designing of implements using bullock power were first taken up. A number of firms co-operated and made their implements available. They were tested under different soil and climatic conditions for efficiency, durability and suitability to varying local conditions and cropping. The defects observed were pointed out to the manufacturers and suggestions were made for their improvement. They were gratefully received by the several manufacturing concerns and they arranged to incorporate the several improvements suggested in their implements. The modified and redesigned implements were tested, approved and finally recommended to the cultivators. A brief review of such tests and short accounts of the new implements designed at the Departmental workshops are furnished in the following sections.

Implements.

The plough.—The plough is the most important implement used in agricultural work in this country. It has been practically the only implement used for several purposes. The indigenous plough is made of wood, is simple in construction and is made at little cost by the village carpenter with the odds and ends of wood available with the cultivator. The body of the plough is triangular in section and pierces the soil and pushes it on both its sides and leaves behind ridges of unbroken land, in-between adjacent furrows. These ridges are broken by cross ploughing. The depth of ploughing is also limited.

The early workers introduced a number of iron ploughs from England and America. These were designed for use with horses, which transmit the traction power with their shoulders. The bullocks pull with their necks, which are higher than the shoulders of the horses. The ploughs had to be readjusted for this kind of bullock traction. The iron plough enters the soil and severs a thin ribbon of soil, by making a horizontal cut at the bottom of the furrow and a vertical cut on the side. This furrow slice moves up the mould board which is continuous with the share and where the furrow slice is gently twisted and turned over. The furrow slice is finally laid down inverted with original under side facing upwards. The original upper surface is laid at the bottom and the surface vegetation is thereby nicely buried inside the soil and the furrow slice is also lightly broken up and pulverised during the process of inversion. The draft required for pulling the mouldboard plough is less than for the indigenous plough taking the same depth.

Plate 167.—An improved plough at work.

A number of ploughs of different shapes and sizes were tried and some were modified and adapted for use in this country. These were later taken for manufacture by Indian firms. The firm that is actively collaborating with the Agricultural Department is Messrs. P.S.G. & Sons Charity Industrial Institute, Peelamedu, Coimbatore. They are the pioneer manufacturers of agricultural implements in South India. Messrs. Kirloskar Brothers & Sons, Kirloskarvadi and Cooper's Engineering Works, Satara, are also manufacturing a number of agricultural implements approved by the Madras Agricultural Department. The iron ploughs and other implements manufactured by these firms, duly tested by the Agricultural Department, are advocated for use by the cultivators. The ploughs recommended and in use can be divided into three classes, as small, medium and large, depending upon their size, the depth of ploughing and the size of the animals with which they are intended to be used.

Light ploughs.—Cooper No. 25 plough, Gurzar No. 2 plough and P.S.G. No. 10 plough may be taken to represent the light type of ploughs. They open furrows four inches deep and five inches wide and are made with cast iron body, steel mouldboard and cast chilled share. They are provided with long shaft poles and single handles and can be worked by a pair of small sized animals. They are useful for light and loose soils.

Medium-sized ploughs.—Cooper plough No. 11, Kirloskar No. 14 and P.S.G. No. 16/C represent the medium-sized ploughs. They are all steel ploughs with chilled cast iron shares suitable for loamy and clayey soils. The mouldboards have excellent scouring properties and the furrow slices are nicely twisted and inverted. They are also recommended for use in wet lands. The furrows taken are five inches deep and seven inches wide. They are worked with medium-sized animals and are equipped with long shaft poles and single handles.

Heavy ploughs.—These are designed for opening furrows six inches deep and nine inches wide and are represented by Cooper No. 34, Kirloskar No. 18 and P.S.G. Nos. 32 and 32-B. They are intended for use with a big pair of animals. They are made of cast iron and are provided with a steel mouldboard. The Ransomes Victory plough is also of the same class and it is made of steel. It is provided with adjustments for regulating the width and depth of the furrows. It is extremely efficient and surpasses other ploughs of the same class. It is very suitable for ploughing stiff clays and for incorporating green manure crops in the soil.

Miscellaneous types.—A number of other ploughs was found suitable for specific purposes in certain tracts, like the bar plough for use in stony soils and reversible disc ploughs for ploughing in green manure and for ploughing sloping lands. Quite a number

of ploughs tested of both indigenous and foreign makes were found to be unsuitable.

The 'Shanti' ryot's implement has been designed for doing various types of work like ploughing, ridging, intercultivating, etc. The implement has a frame to which iron parts designed for the several items of work are fitted as desired. The moving parts are of simple design and spares could be easily made and fitted by the village smiths. The implement is found suitable for small-scale cultivators, who cannot afford to purchase several implements for different cultural operations. It must, however, be said that the multi-purpose implement is not so efficient as the single-purpose implements specifically made for the several individual jobs. Further improvements and modifications of the Shanti implement are being worked out at the research centre.

Ridge ploughs throwing earth on both sides and opening a central furrow are useful for planting cotton, sugarcane, chilly, etc., in rows. The ridge ploughs or ridgers made by the indigenous companies are of cast iron and the share point is renewable. The furrows opened are nine inches in depth and 20–22 inches in width. The ridgers can be worked with a pair of bullocks.

The ridger designed at the Departmental Workshops has hinged mouldboards to regulate the width of the furrows from 16 to 26 inches and the depth within reasonable limits.

Blade harrows.—These implements have an iron blade fixed by two standards to a wooden frame, wherein are attached the handle and the shaft pole. When the implement works, the iron blade moves under the surface of the soil and separates a layer of soil from the firm ground below. This is in common use in the northern districts of the State and is called a '*Guntaka*'. The *guntakas* are largely used for preparing the land and smaller types are used for purposes of intercultivation.

Messrs. G. R. Hilson and D. G. Munro of the Madras Agricultural Department designed improved models and patented them by the name of 'H. M. Guntakas'. These were made in three sizes and named No. 0 with six inches blades for intercultivation, No. 1 with 15 inches blades and No. 2 with 24 inches blades, either straight or curved. The curved blades were for greater depth and easier penetration. The design permitted variation of the angle formed by the shaft pole and the blade to suit the height of the animals used for traction. These *guntakas* were sturdily made and were efficient, but their cost was too high for the cultivators and the new models did not become popular.

R. E. Guntaka.—This was designed by the Research Engineer to provide a good clearance between the blade and the shaft pole, for the passage of clods in an unobstructed manner. These were provided with 24 and 36 inches blades and reversible points attached

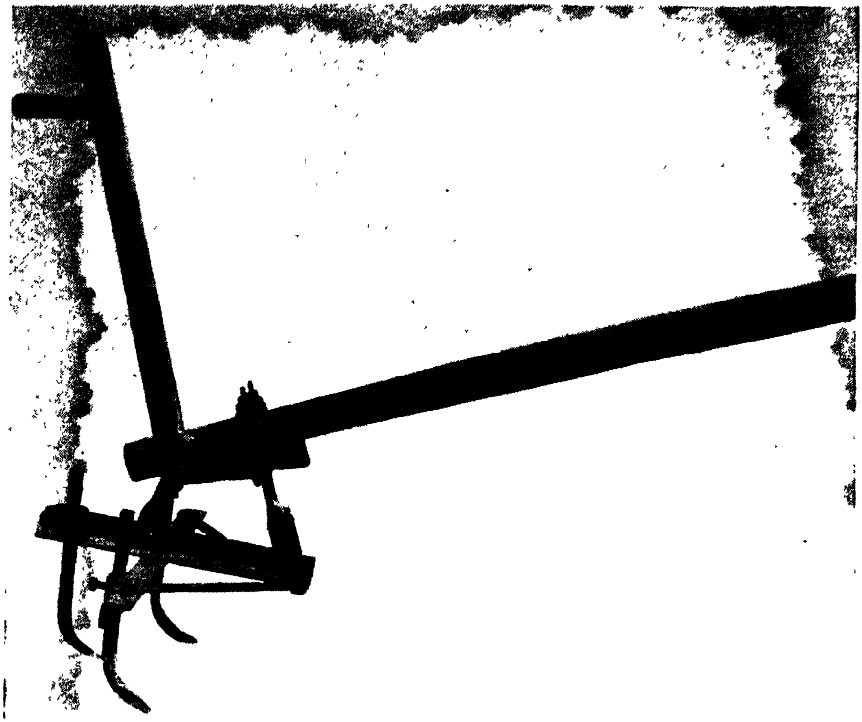

Plate 168.—*Shanti ryots' implement fitted with a mould-board plough.*

Plate* 169.—*Shanti ryots' implement fitted with a ridger.

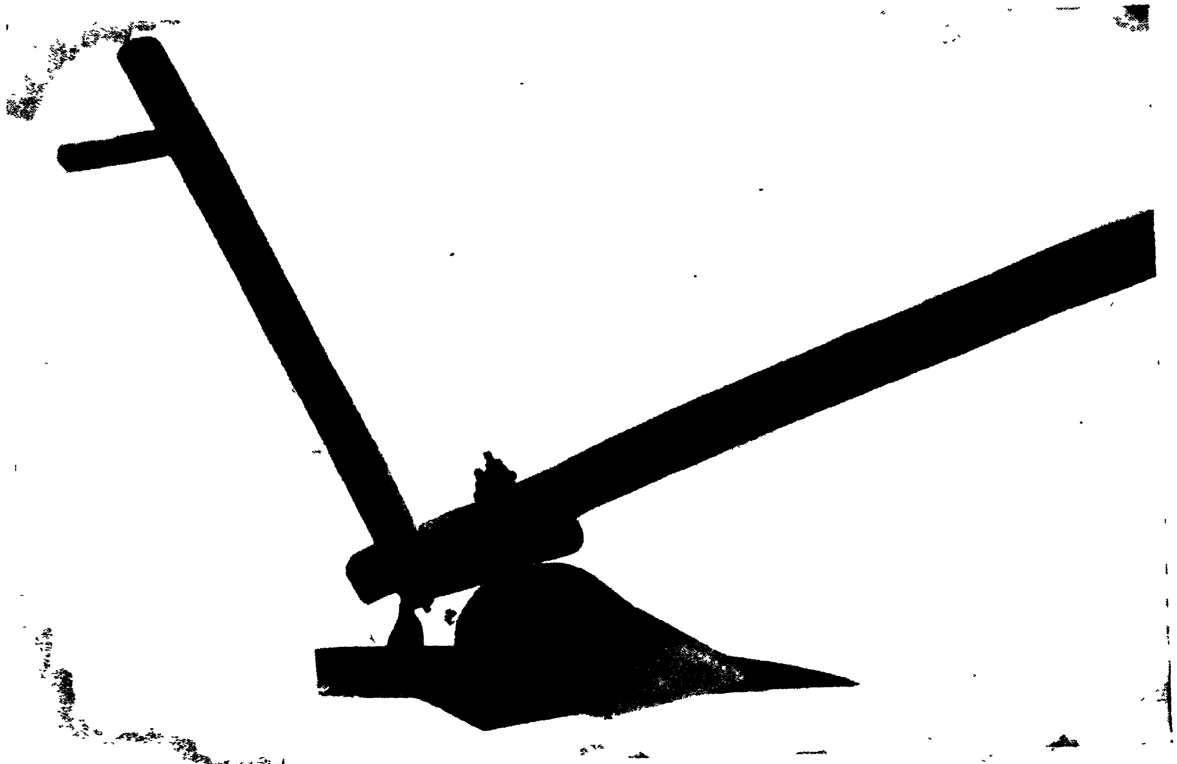

Plate 170.—*Shanti ryots' implement fitted with a* 3-*tyned adjustable hoe.*

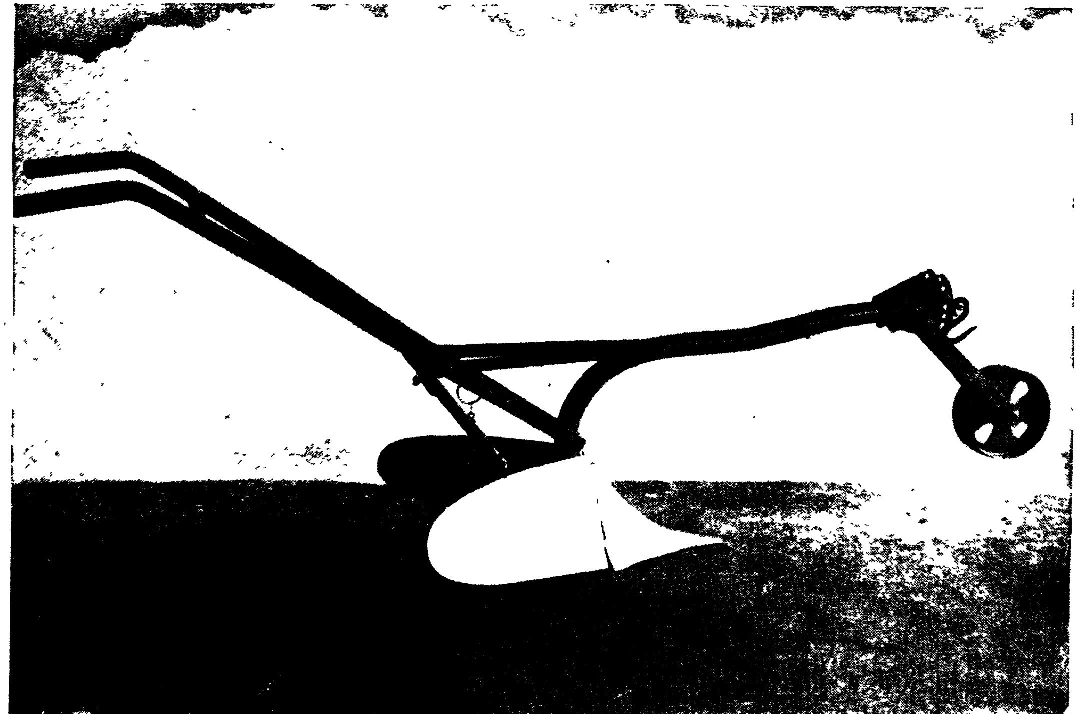

Plate 171.—*Ridger.*

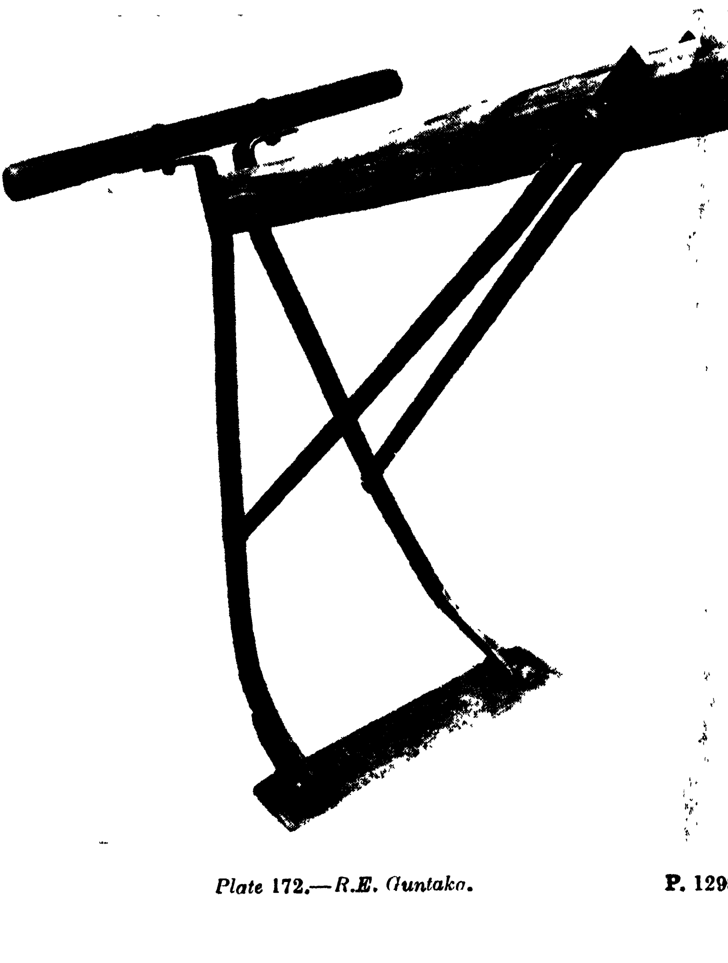

Plate 172.—R.E. Guntaka. **P. 1298**

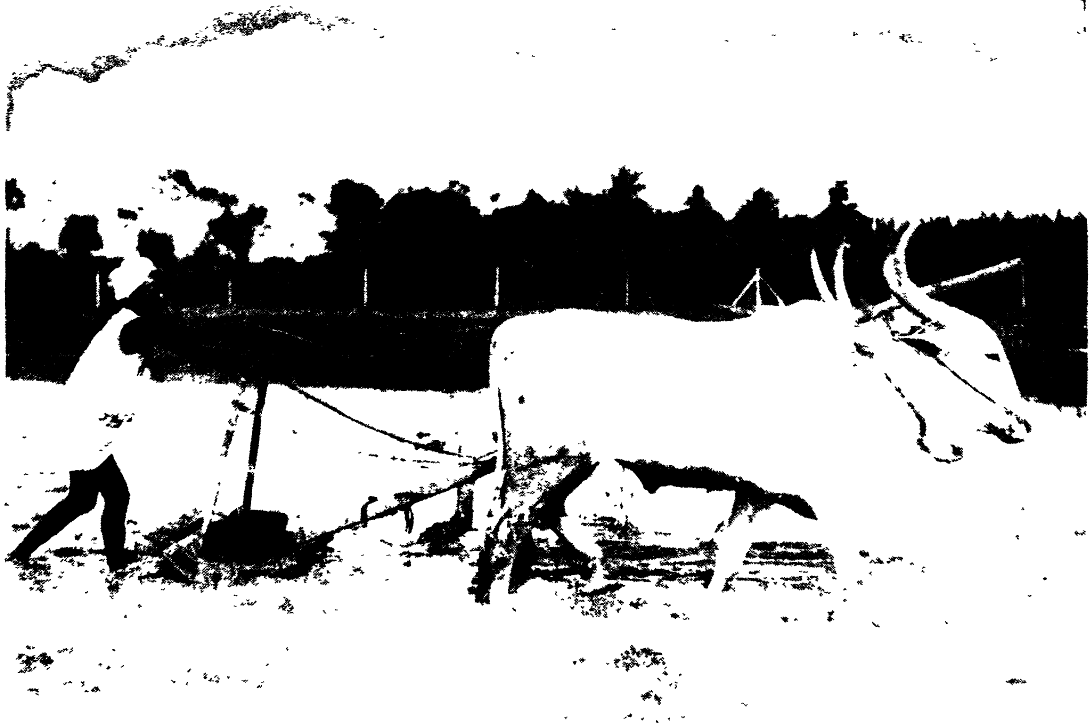

Plate 173.- Wet land puddler

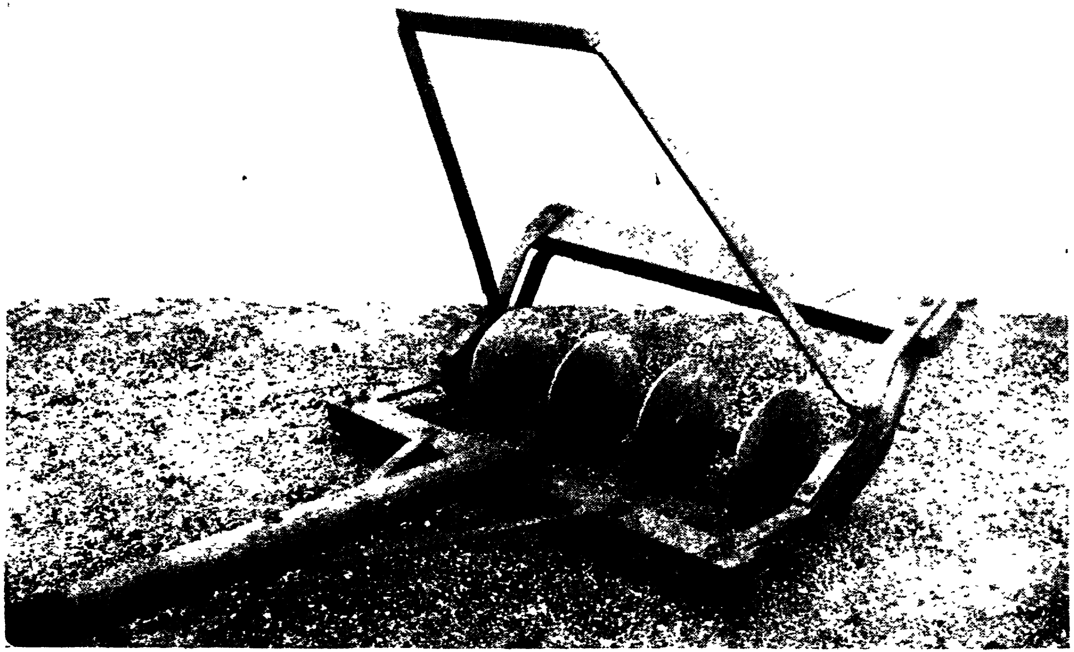

Plate 174.—*Green-manure trampler.*

Plate 175.—*Bund former.*

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in front of the blades to help penetration in hard soils. The R. E. Guntakas work satisfactorily, break the clods in the field, mulch the soil and harvest groundnuts, in loamy soils that are lightly moist.

Wetland puddler.—The puddler is a useful implement that brings about nice puddling of loamy wetland soils, after working the plough preliminarily. In very light soils, preliminary ploughing may not be absolutely necessary. It was designed at the Department Workshops on the model of the Burmese '*Settun*' and has inclined plates mounted on cast iron hubs fixed to an axle. These blades revolve when the implement is worked, churn up the clods of soft mud, disperse the mud particles and keep the mud suspended in water nicely for planting rice. The implement works best in light and loamy soils with two to three inches of water standing on the surface. In the heavier soils, mud tends to cling to the blades and clog the implement. A little more water in the field may help to an extent. As the field is left in a levelled condition by working the puddler, there is normally no need to work the levelling board, before planting rice. The puddler covers about two acres in a day.

Green manure trampler.—The implement designed at the Departmental Workshops consists of steel discs with cast iron hubs mounted rigidly on a horizontal shaft rotating in wooden block bearing bearings. When the implement is worked in the puddle, it is able to thrust into the soil, green manure plants spread on the surface and incorporate them nicely with the soil. It covers two to three acres in a day working with a pair of bullocks.

Bund-former.—This implement is used for putting up bunded compartments in the field for irrigating the garden lands, for preventing the flow of run-off water during rains in dry lands and for retention of rain water to allow absorptions and saturation of moisture by the soil to enable luxurious growth of the crops grown there. These bunds also check soil erosion in gently sloping lands, if properly put up. The implement puts up big compartments over eight to ten acres in a day with a pair of bullocks in dry lands and small compartments or beds in one and half to two acres of garden lands.

The bund-former designed at the Departmental Workshops consisting of a pair of long sweeping wings fixed suitably on both the sides of the shaft pole. The wings are wide apart in front and converge towards the rear end, leaving a gap finally for the formation of the bund. The size of the bund is regulated by the size of the wings and the adjustable opening at the rear end. The bund-former is made in three sizes, with two and a half, three and a half and five feet long blades to suit the size of the bullocks. The angle of the shaft pole can be adjusted to suit the size of the animals.

Fertilizer distributor.—Where large quantities of concentrated fertilizers are used for crops, it has to be uniformly distributed in the field. The implement designed at the Departmental Workshops distributes the fertilizer through spouts and the rate of flow of the fertilizer closely follows the speed of working the implement over the land, with facilities for closing the spout when the implement is stopped at the end of the field for turning. The spout distributes the fertilizer in bands four inches wide and facilitates the passage of lumps up to one-eighth of an inch in diameter.

Buck scraper.—This implement is also called the 'Earth Scoop' and is made of a single piece of thick mild steel plate, lapped and rivetted at the corners, to form a rectangular box, with the front end open. Two flat steel runners on the underside stiffen the scoop bottom and take the wear. The implement is perfectly balanced so that the box gathers loose earth, when the backside is lightly lifted. The gathered earth is dumped in hollows or wherever required by giving a light push to tilt the contents. The front end is provided with teeth to facilitate proper penetration of the end in the soil. The implement is used for levelling fields, excavating ditches and for doing work involving movement of soil from one place to another, over short distances. The implement works satisfactorily only when the soil is loosened by ploughing preliminarily. It is available in two sizes of two and three cubic feet capacity and is worked with a pair of animals.

A number of types of buck scrapers were tested at the Departmental Workshops and the implement was redesigned to suit the conditions prevailing in this country. The redesigned model is being made by Messrs. P.S.G. & Sons.

Basin lister.—This is a special implement designed for use in dry farming areas and sloping lands, to hold rainwater in small pockets formed on the soil surface and prevent it from flowing over the land, causing soil and water losses. The implement has two or more furrowers mounted on wheels. The furrowers are lifted periodically while working by an eccentric cam arrangement and when the implement is worked over a field, dammed furrows are formed, which hold the rainwater, allows percolation of more water into the soil in course of time and prevents heavy run-off during rains, thus conserving the soil and moisture so very necessary for plant growth.

Twin furrow listers are suitable for use with bullocks and about four acres could be covered in a day. The implement is worked along the contour, that is across the slopes.

Cultivators.—They are used for cultivating interspaces between rows of crops sown in lines. Intercultivation serves the same purpose as hand hœing and weeding and saves time and labour. The cultivators are provided with a framework to which are attached a varying number of tynes, usually five. The tynes are

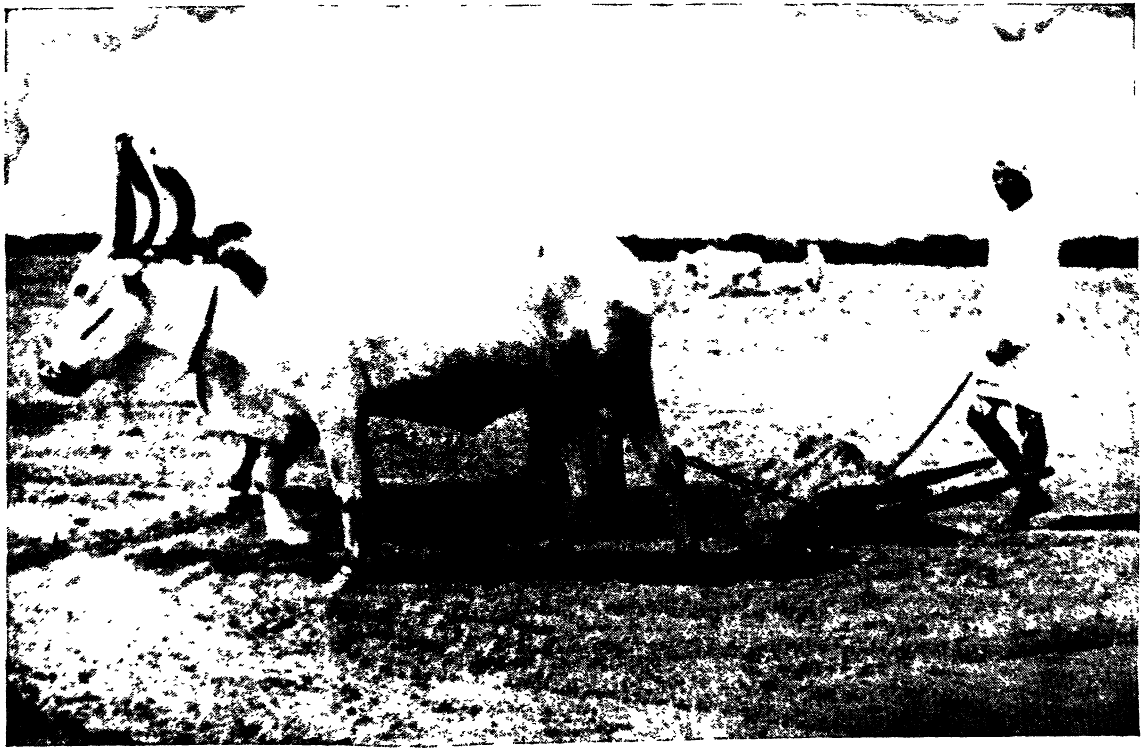

Plate 176.—Buck-scraper.

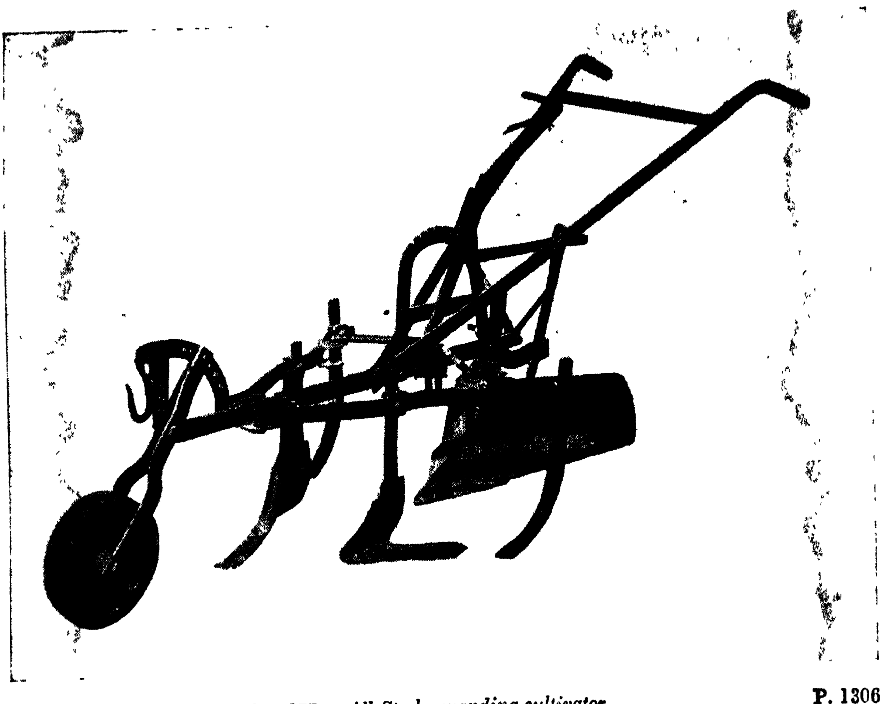

Plate 177.—*All Steel expanding cultivator.*

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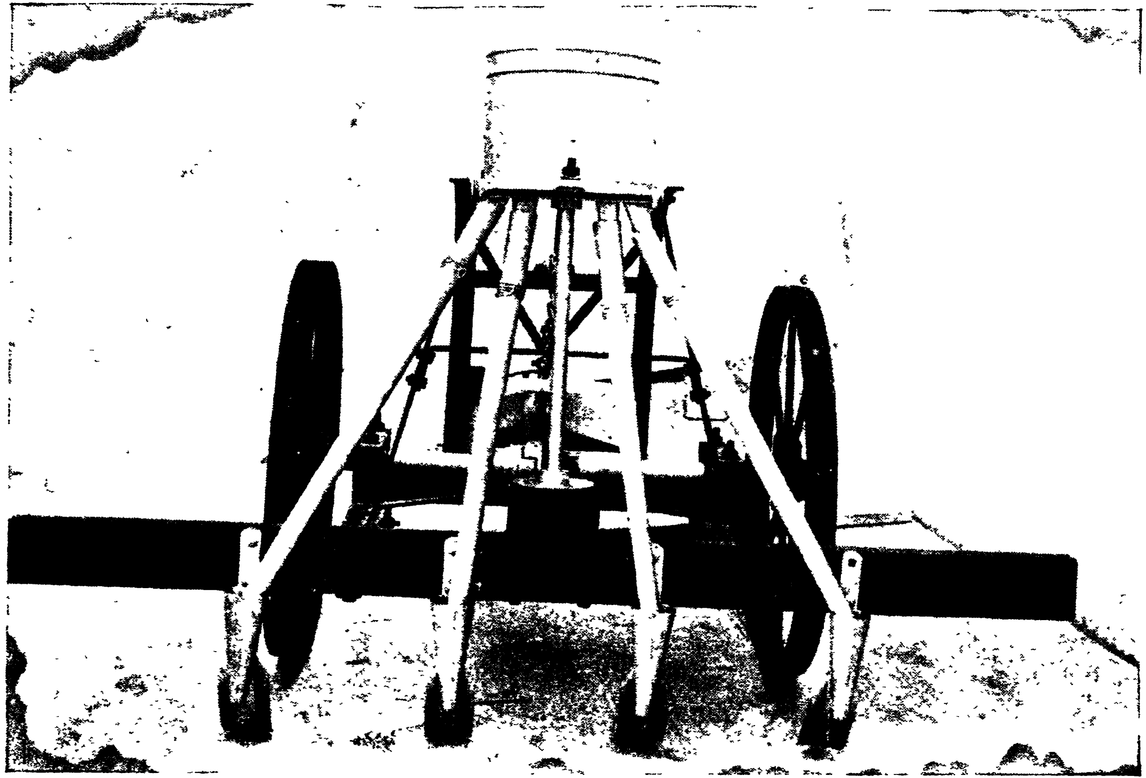

Plate 178.—*Mechanical seed drill—4 tyred.*

available in various shapes and sizes to suit the crops. The width covered is adjustable and it facilitates the implement being worked between crop rows of varying widths. The implement can be worked with a pair of animals of ordinary size, or by a big sized bullock, fitted with a single bullock harness. McCormic Deering cultivator No. 54, John Deere No. 306, Planet Junior Hoe and P.S.G.'s five-tyned cultivators are all capable of doing good work, in between crops sown in lines two to three feet apart, like sugar-cane, cambodia cotton, tobacco, root crops and the like.

Seed drills.—The seed drill is an implement used for sowing seeds in rows, parellel to and equidistant from each other. A simple type of seed drill, called '*gorru*' has been in use in Rayala Seema, a predominantly dry farming tract. A number of tynes shaped like the indigenous plough bodies are fixed to a horizontal beam, at equal distances. The tynes have holes through which the seeds drop in the furrows. There is a seed hopper at a height of about three feet, where seed is distributed with the hand. There are as many holes at the bottom of the hopper as there are tynes in the *gorru* and tubes connect these holes to those in the tynes, through which the seeds dropped in the hopper pass to the tyne furrow. The *gorru* is cheap, efficient and is easily made in the villages. It was however seen on testing that the quantities of seed passing through the several tynes were not uniform and the variation was as great as 1 : 2. That means that the seeds sown in a line are twice as much as that sown in another. The stand of the crops should therefore be expected to be not uniform. The uneven stand of plants in the rows is due to the human element in distributing the seeds in the hopper.

A mechanical seed distributor designed at the Departmental Workshops was attached to the *gorru* and it distributed the seeds satisfactorily. Later the design was completely changed to ensure uniformity of distribution of seeds and flexibility of the drill for sowing different crops, using varying seed rates. The drill is mounted on wheels and the seed drum is placed centrally above the line of the furrow openers. Tin tubes radiating from the seed drum carry the seed to the furrow openers, as in the case of the *gorru*. The furrow openers are sturdily made of iron and placed at the rear end for ease of inspection and adjustment of the spacing between the rows when necessary. The depth of the furrows is made adjustable to suit the kind of seed used. Big seeds require deep sowing and small seeds are planted near the surface.

The seed plate fixed at the bottom of the seed drum is changed for sowing different crops and for using different seed rates. A clutch is provided to keep the seeder out of operation, while turning at the ends of the fields. A hand lever is provided for lifting the furrowers clear of the ground, when the drill is moved over the head lands. The drill has a seat for the driver and lends itself

for use as an intercultivator in fields sown in lines and as a general purpose cultivator by the addition of a few more dummy furrow openers. The new drill is now made by Messrs. P.S.G. & Sons and has been appreciated by people who have seen it working, both in this State and outside.

MACHINES.

Thrashing and winnowing machines.—Separating the grains from the earheads or thrashing and winnowing or separating the grains from the chaff, dust and soil particles from the thrashed grains are all done by human labour, aided in certain cases by cattle power. Thrashing and winnowing are laborious operations that consume a lot of time. Winnowing is dependent on the winds that blow at the time, for the efficient cleaning of the grains. Thrashing and winnowing machines have been developed in the western countries and help greatly in taking the tedium of these operations. A few thrashers and winnowers were tested at the Departmental Workshops at Coimbatore and found suitable for use in this country and economical too. But the individual farming units here are in general so small that they may not be able to stand the initial cost. It may therefore be suggested that people could jointly purchase and make them available for the several participants or in the alternative individual cultivators could purchase them and hire them out to their neighbours at rates covering the depreciation charges, operational costs, interest on the capital invested and a little profit. It may be mentioned that this form of owning agricultural machinery has developed rapidly within the past few years in parts of America and small farmers have been benefited to a large extent.

The thrashing machines are operated either by electrical power or by small oil engines. The earheads of plants and in some cases whole plants themselves are fed to a revolving drum which strikes the ears against a fluted concave, when the grains are separated from the ears. The grains pass through the concave and get subjected to a blast of wind blowing off the chaff and the empty glumes. They then pass through sieves of different sizes. The bigger ones retain the empty ears only. The next one retains the thrashed grains allowing the broken grains, dust and soil particles to pass through the meshes. The cleaned grains are passed through a spout for bagging. The winnowing machines do all these jobs, excepting the thrashing and the separation of the grains from the ears. They are useful for cleaning the grains separated from the ears by other methods. The winnowing machines are small units comparatively and are operated by manual labour.

Garret portable thrasher.—This machine made by Messrs. Agricultural and General Engineers, London, was tested. It is made of iron and mounted on cast iron wheels with a swivel in

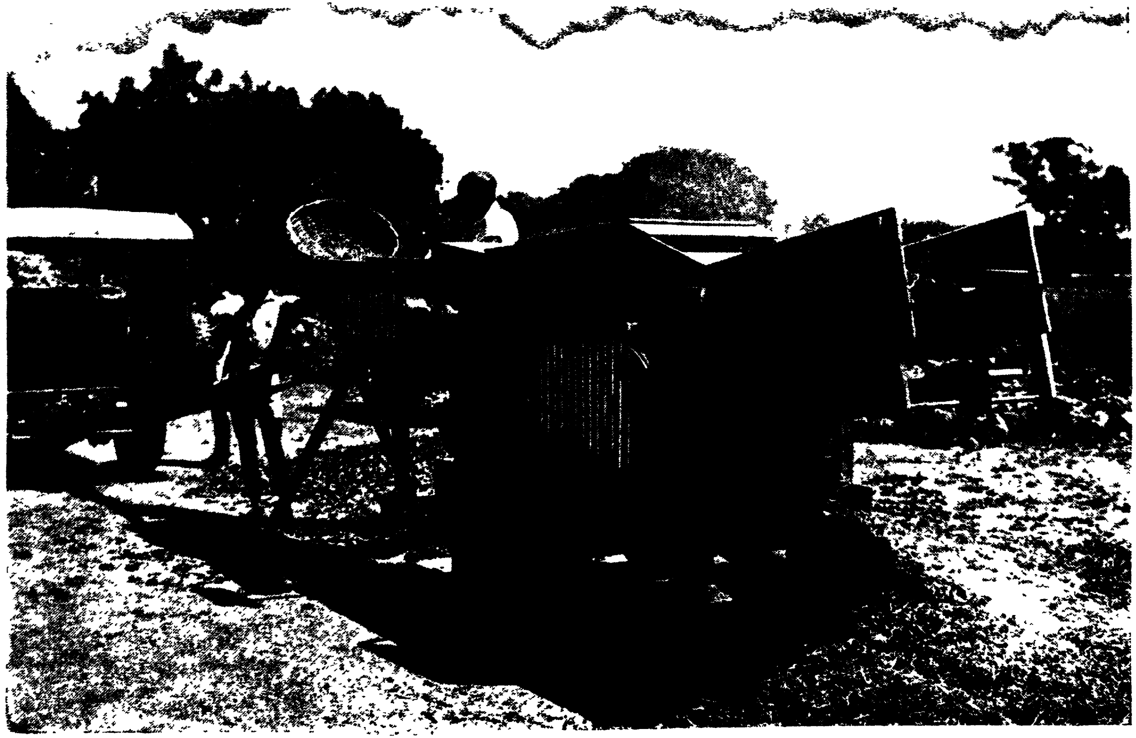

Plate 179.—*Dania Thrasher.*

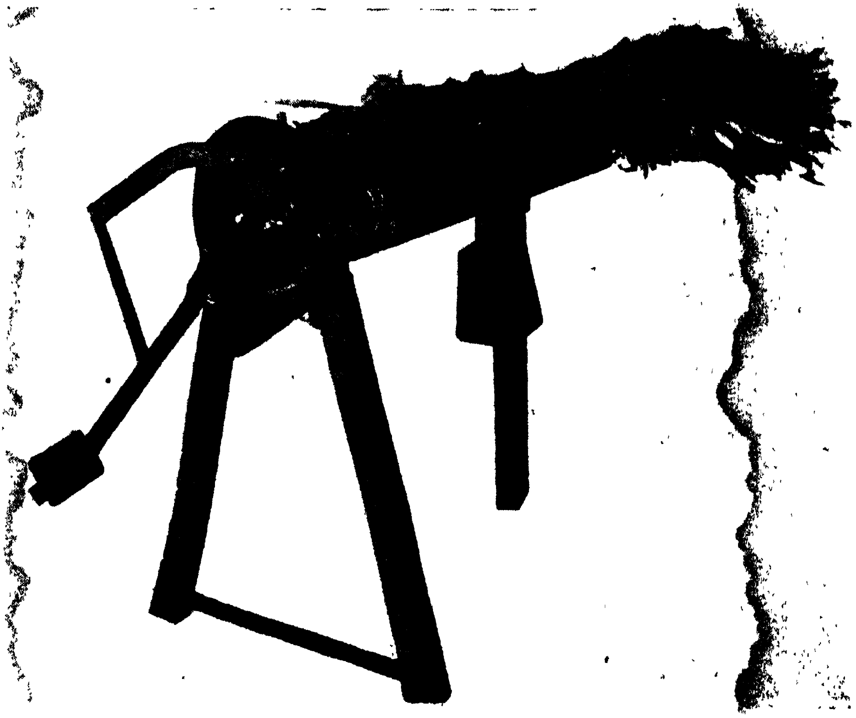

Plate 180.—Foot-operated chaff cutter.

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the front axle for turning and a hook in front for haulage. It requires a three H.P. drive for operation. The cost of the machine was Rs. 432 in 1932, when it was purchased. The machine separates nearly five tons of sorghum grains in a day of eight hours. It saved Re. 1 per ton in thrashing when compared to thrashing with cattle and manual labour in 1932.

Dania thrasher.—This was imported by Messrs. Indo-Danish Corporation from Denmark. It thrashed most of the grains grown in South India. The defects noted in its working were intimated to the manufacturers for rectification.

P.S.G. thrasher.—This is designed on the model of the Garret thrasher. Trials made with the machine were satisfactory. With sorghum, 1,270 lb. of ears gave 960 lb. of grain in an hour, with a consumption of four units of electrical energy. It thrashed 1,100 lb. of *ragi* grains per hour and the cost of operating the machine worked to Re. 1 per ton of *ragi* and Rs. 1–3–0 per ton of sorghum in 1940. Four men and four women were required for feeding the machine, bagging the grain and transporting the produce.

Winnowing machines.—Messrs. P.S.G. & Sons made winnowing machines more or less on the same lines as those made by Messrs. Richard Corbett & Co., Strawberry, England. Certain defects noted in the machines made originally were got rectified and the new machines were tested at the Agricultural Stations at Coimbatore, Anakapalli, and Koilpatti. They cleaned rice, *ragi*, sorghum and *bajra* grains satisfactorily and economically. Four to five tons of rice grains were winnowed and cleaned in a day of eight hours.

Chaff cutters.—These machines are designed for cutting dry and green fodders with hard stems into small bits to avoid wastage of fodder, by being pulled down by the cattle and getting soiled. Further, the cattle consume actually more of cut fodder than long material. A number of types of chaff cutters were tested and indigenous makes compared favourably with the imported ones. The chaff cutters are mainly of two types; one employs a rotating wheel with two or three cutting knives attached to the radial arms of the wheel while the other has a hinged cutting knife which is raised and lowered for cutting the fodder. The circular types are operated by manual labour, bullock power or power drive, while the guillotine hinged type is operated by hand. A suitable model has been designed for operation by the legs, combined with feeding of the fodder by the hands of the same operator.

The capacity of the chaff cutter varies with the type of power employed. The foot operated type chaffs 200—300 lb of fodder per hour and the cut pieces are two to three inches in length.

Ce-co-co Rice sheller.—This is a rice sheller model originally introduced from Japan, adaptable for work with manual labour or power drive, depending upon the size of the huller. It operates on a new principle. Paddy grains are poured in a thin stream

over a horizontal plate rotating fast. The grains are thrown out from the plate with a great momentum and they strike against a cylinder lined with a hard rubber composition. On striking, the hulls get split and the rice kernel is released.. There is a certain amount of unshelled paddy, which has to be separated and passed through the sheller again. The proportion of rice to paddy is as high as 75 per cent by weight. The paddy is simply shelled and the bran layers are intact adhering to the shelled grains. The vitamins and the mineral salts are retained with the grain and are not lost, as is happening with every other methods of hulling. There is an amount of breakage of grains when rice is shelled by this sheller, particularly with long grained varieties.

The separation of the hulls from the rice has been done successfully at the Departmental Workshops with the help of a small winnower designed for the purpose. These are now made for distribution by Messrs. P.S.G. & Sons. The shellers are sturdy and the composition rubber cylinder lining requires to be renewed off and on. The hand-operated sheller requires a batch of four men and four women for operation and a bag of paddy is shelled and cleaned in an hour. The sheller is a good mechanical device for shelling paddy, suitable for villages, where shelling paddy could be taken up as a cottage industry.

The wooden grinder.—This consists of two flat cylindrical pieces of wood placed one over the other, more or less like the stone grinder used for grinding flour. The two opposing faces of the wood have radial grooves and when paddy is fed at the top, it gets distributed between the two grinding faces and when the top is rotated, the paddy is shelled by the rubbing circular movement and the rice is later separated by winnowing. The breakage of the rice during shelling is often great. Trials are on way to reduce the pressure on the grains by mounting the top on a ball bearing. When the pressure is reduced, there is a tendency for the shelling efficiency to get reduced.

Sugarcane crushers.—In the sugarcane mills originally in use in the country, there were two wooden rollers rotating in opposite directions for crushing canes and extracting the juice. The wooden rollers were first replaced by iron rollers and in the present form an additional roller is provided for efficient crushing. A number of makes of mills on the market were tested at the several Agricultural Stations. The P.S.G. Mill, Sultan Naha Mill and Kirloskar's Kumar bullock-driven mill were efficient and gave juice extraction ranging from 70—71 per cent on the weight of canes. The first two mills crushed four cwts. of canes in an hour and Kirloskar Kumar handled three cwts. The new Hathi Mill, R. N. Banerjee Mill, Mr. Crown Mill, Kirloskar Kamal, Aswani Kumar Mandal and Fakir Chand Mill were the other mills tried and their efficiencies were less. Among the power-driven mills, Kirloskar's Vasant, a horizontal type, was the best and gave an extraction of 72 per cent of juice.

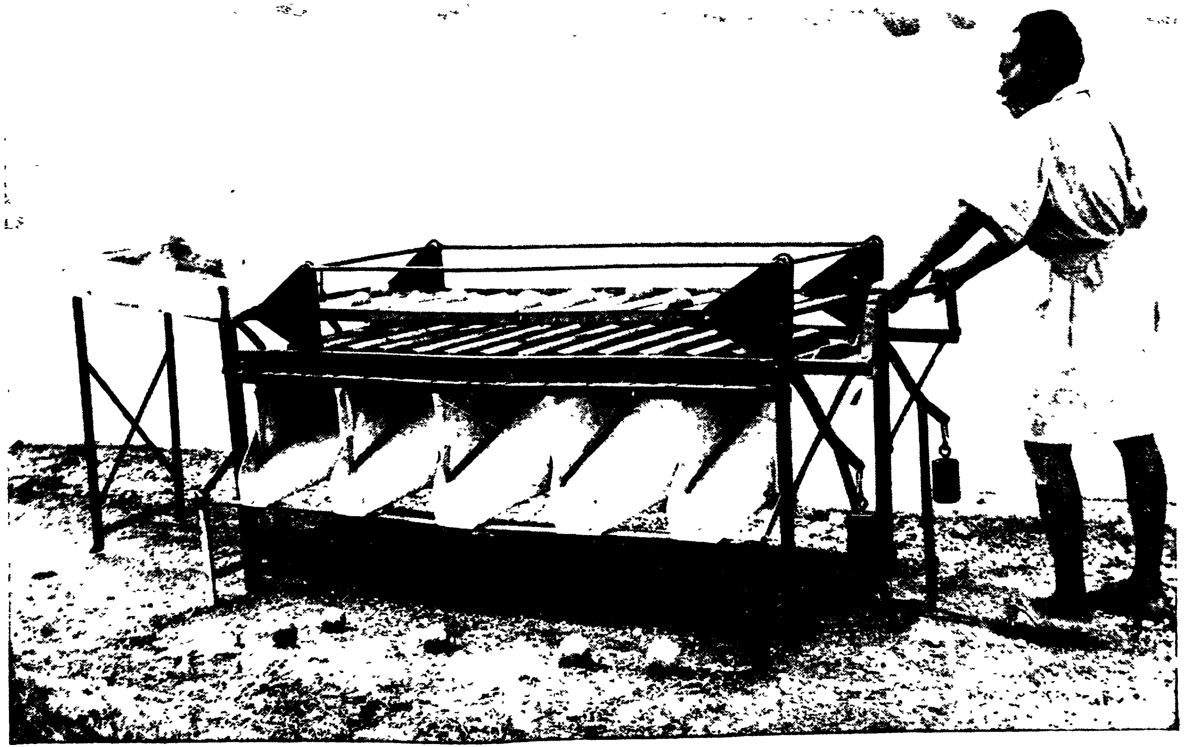


Plate 181.—*Orange grader.*

Plate 182 —*Potato grader.*

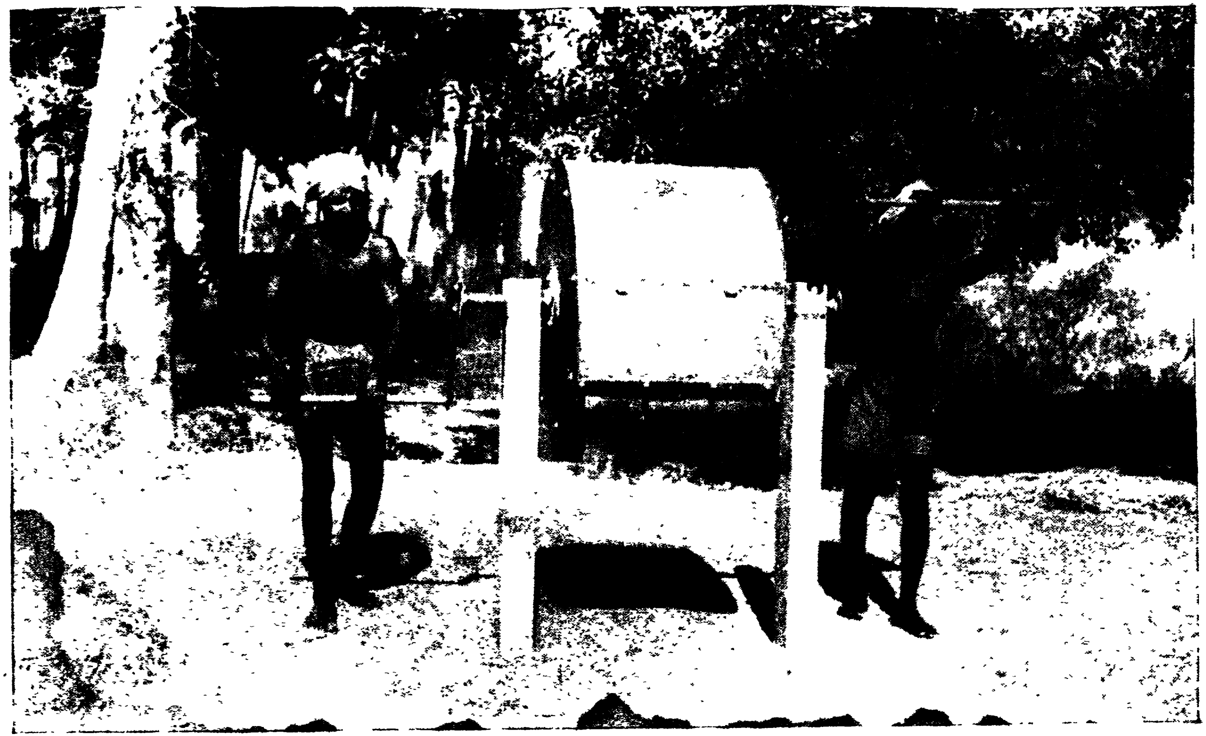


Plate 183.—*Turmeric polisher.*

Seed treating drums.—This is a convenient device designed at the Departmental Workshops for dressing seeds with fungicides like sulphur before sowing. It consists of a four-gallon drum mounted on an axle passing diagonally through the cylindrical drum, with an opening for feeding and emptying the drum. When the drum is charged and rotated, the seeds get uniformly coated with the fungicidal dust that is added. The design incorporates the idea of the seed dusting wooden drum in use by the Department of Agriculture, Madhya Pradesh.

Hay and straw presses.—Hand-operated hay and straw baling presses manufactured by William Jacks & Co., costing Rs. 1,856, P.W.D. Workshops and a Danish Press supplied by Messrs. Agricultural Equipment Co., Madras, for Rs. 3,000 were tested for baling straw. The first two baled little over a ton a day and the Danish Press baled five tons a day. Considerable redesigning may be necessary for evolving a suitable model at a reasonable cost.

Graders.—An egg grader was designed for automatically grading eggs by weight into five grades weighing two and a half, two, one and three-fourths, one and a half, and one ounce each. The tests with grader showed that eggs could be satisfactorily graded by weight. The grader handled 840 eggs in an hour and there was some breakage during handling. With further refinements, it may be possible to eliminate breakage of eggs during grading.

Graders were also designed for grading oranges, two and a quarter to three and half inches in diameter, with quarter inch range between the grades and a capacity of 7,000 to 8,000 fruits per hour. A similar grader is suitable for grading lime fruits. A modified design grades potatoes from one and a quarter to one and three-fourths inches in size and grades outside this range up to 1,200 lb. per hour.

American made Vac-A-Way seed graders originally intended for oats, barley, etc., and operated by manual labour and power were tested with paddy, sorghum, *ragi*, coriander, etc., and found satisfactory. The graders clean the grain of the admixed chaff and dust, if any, and later separate the grains into grades depending upon the size, with sieves of suitable mesh.

Turmeric polisher.—The cured turmeric was polished originally by mixing with sharp-edged stone jelly and rocking them in bamboo baskets swung on tripods. The polishing was laborious and inefficient. A horizontally mounted barrel, two feet long and three feet in diameter, made of expanded metal and covered over with quarter inch wire mesh was designed. The barrel is rotated by two men and a charge of 70 lb. of turmeric is polished in seven minutes, with the barrel rotating at 30 revolutions per minute. The rootlets and scales attached to the turmeric rhizomes get detached by rubbing against the angular expanded metal and the turmeric is properly polished. These polishers are in demand in

turmeric areas and they are now made by Messrs. P.S.G. & Sons and Cooper Engineering Works.

Hand gins.—Some gins operated by hand for separating lint from seed cotton (Kapas) were tested. The local wooden hand gins separated three-fourths lb. of seed cotton per hour and the output was very low. The improved hand gin made by Khadi Vastralaya, Ahmedabad, handled two lb. per hour, but was not suitable for the American cottons like Cambodia, which had big sized seeds. The D.C. hand gin built in the same way as the power gins costing Rs. 200—400 each handled four lb. of seed cotton. A small gin made by Athens Machine Co. Texas handled satisfactorily eight lb. of seed cotton per hour. Messrs. P.S.G. & Sons have made two types, one big and one small, and both work satisfactorily.

Groundnut decorticator.—Groundnut kernels are separated from the pods by the ryots by spreading the pods in thin layers and beating them with sticks. The operation is laborious and costly and breakage of kernels is high and this reduces the market value of the kernels. Kirloskar's Kalyan, a Branda system decorticator and a Chinese type were tested. The Chinese type was the most satisfactory and it has been improved by incorporating adjustable clearances between the grid and the beater and change of grids to suit different sized kernels. The kernels obtained are free of skin damages and breakages and the output is one ton of kernel a day of eight hours. This is now recommended for use by small-scale growers.

Arecanut dehusking.—Areca fruit peeling with the special knife called '*Mettukathi*' is a slow and laborious process. Unless the fruits are dehusked within two days of picking, they get ripe and unfit. Attempts made to design machines for dehusking have not been successful so far.

Dehydraters.—A small dehydrating unit for handling sweet potatoes in the villages was designed. Though dehydration was successfully done with this unit, the cost of labour and fuel tended to raise the cost and make dehydrating uneconomical. Work on this was therefore discontinued.

Sprayers.—Sprayers are contrivances designed to spread appropriate chemical solutions in extremely thin layers over plant surfaces in a uniform manner, to combat pests and diseases. The efficiency of spraying depends on the fineness of the nozzles and the pressure that is developed to force the liquid through the nozzle, and break the liquid into fine mistlike particles. A number of sprayers were tested and Hyject sprayer supplied by Messrs. Anand Bros., Calcutta, and the Atlas compressed air sprayer with a capacity of 80 gallons per hour were found to be efficient. These are being recommended to cultivators. A.R.P. stirrup pumps released after the war were suitably modified and used for small-scale spraying.

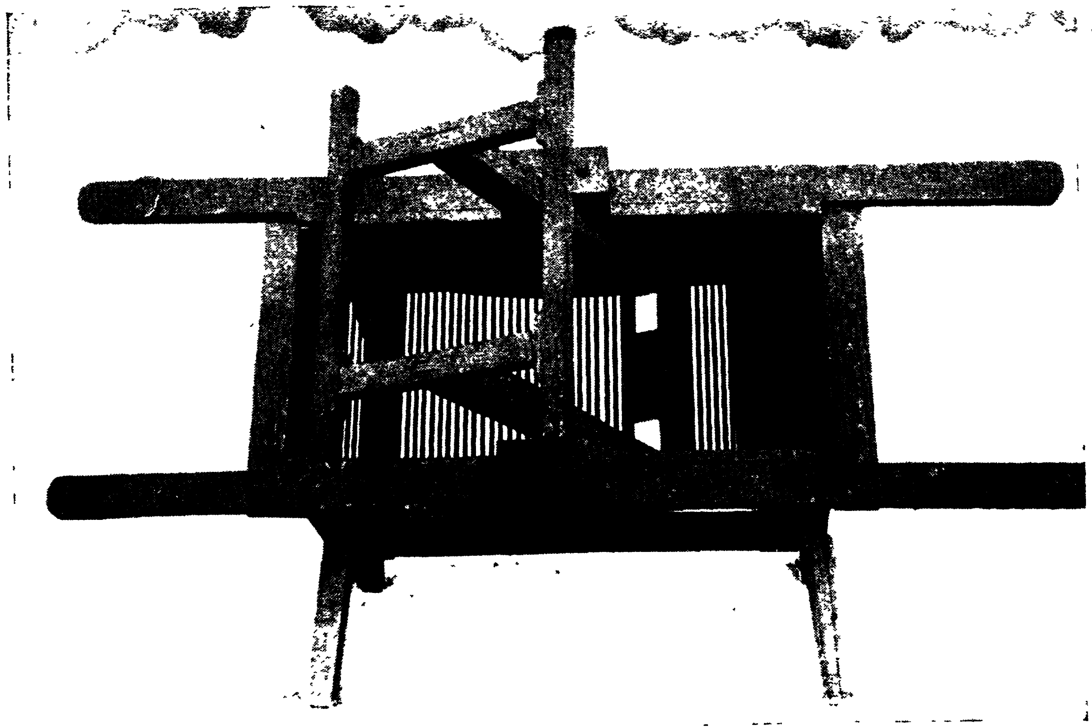


Plate 184.—*Hand operated groundnut Decorticator.*

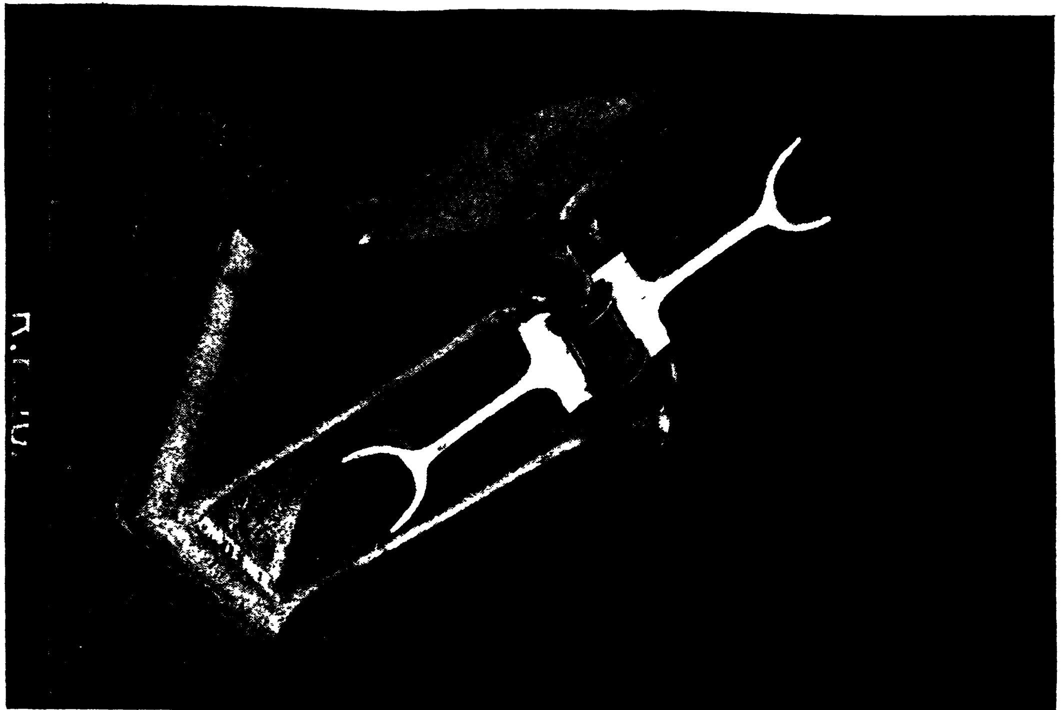


Plate 185.—P. S. G. Ball bearing mhote wheel.

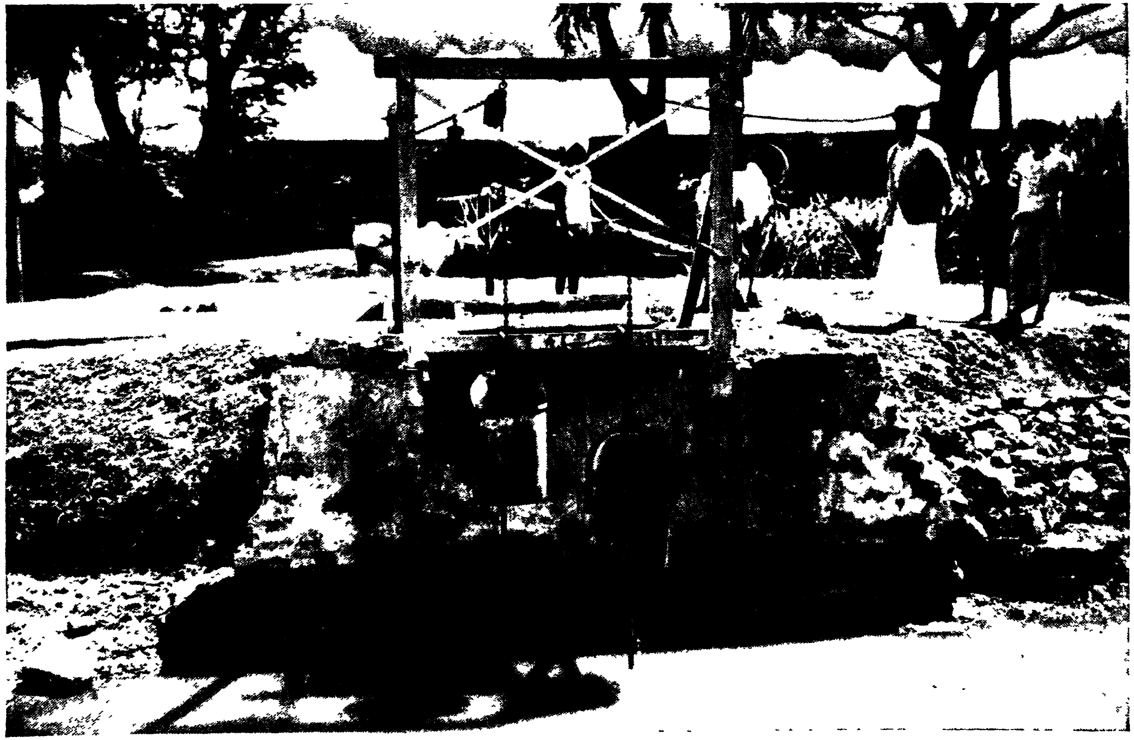


Plate 186.—*Improved circular mhote.*

F. 1323

WATER LIFTS.

Lifting water for irrigation is one of the strenuous operations in agriculture and from the beginning intensive study was made of the various water lifts in use with a view to effect improvements and save labour and energy. The ordinary mhote wheel was hard on the animals on account of development of considerable friction between the moving surfaces. These were replaced by cast iron mhote wheels with roller and ball-bearings and the draught was considerably reduced, which was much appreciated by the ryots. Automatic tilting of the buckets was introduced in the South Arcot circular water lift. This also was taken up by the ryots rapidly.

The various types of water lifts were systematically tested for their efficiency and economy and the results of the several tests are incorporated in the accompanying statement.

Wind mills.—A wind mill made by James Alston Pty., Ltd., Melbourne, Australia, was erected at the Central Farm, Coimbatore, over a 40 feet steel tower and geared to a six inches brass cylinder pump. The maximum output of water lifted was 13,280 gallons a day in June and the minimum was 1,453 gallons in April. The mill could not meet even the minimum irrigation requirements. Another wind mill erected on a 30 feet tower with four-inch cylinder pump at the cattle farm at Chintaldevi was not more successful.

The observations at Coimbatore and Chintaldevi indicated that for irrigation purposes, average wind velocity of at least ten miles per hour was necessary, while for industrial and household purposes, velocities of six and four miles per hour respectively might suffice. Anemometer records maintained at ten different stations in the State showed that wind velocities were high during the monsoon months when irrigation demands are negligible and low during dry periods when irrigation is most required. Provision of large storage tanks for storing water is too costly, and it may be said wind mills are not likely to be useful in this State for irrigation purposes under the prevailing wind conditions.

Kennel's oscillator irrigator.—An oscillator irrigator was purchased for Rs. 715 from Messrs. Merk Seymour & Sons, Limited, for testing the possibilities of spray irrigation. The machine is operated by hydraulic pressure generated by a centrifugal pump driven by a 30 h.p. V. 8 Ford engine. The water is lifted and carried through duraluminium pipes, fitted with spray nozzles every third feet. The spray pipes oscillate to and fro and help to force water as misty spray about 40 feet on either side of the pipes. The oscillating pipes can be moved about the field to bring about suitable coverage. Seven thousand five hundred gallons of water can be sprayed over an acre of land to a depth of quarter inch. Insecticides, fungicides and fertilisers can be applied to the field along with irrigation water. The equipment should prove handy and useful for sandy areas, where loss of water by seepage is bound to be great. The crops should be raised according to a pre-determined plant to facilitate movement of the pipe line without damage to crops.

PERFORMANCES OF WATER-LIFTS.

Name of lift.	Lift height in feet.		Bucket capacity.	Gallons per hour.	Commandable area in acres.	Working cost per day.			Expenditure per acre average.			Cost of installation.			Remarks.
	FT.	FT.				RS.	A.	P.	RS.	A.	P.	RS.	A.	P.	
1 Picottah	10	15	10 gallons ..	2,000	2·4	3	2	0	15	0	0	30	0	0	
2 Trough lift	2	5	12 „ ..	2,400	3·1	3	2	0	9	11	0	15	0	0	
3 Swing basket	2	4	2 „ ..	1,440	1·7	3	0	0	20	0	0	2	0	0	
4 Archimedian screw ..	2	5	Drum 6′ × 1¼′.	5,000	6	3	4	0	6	0	0	100	0	0	
5 Single mhote	20	30	35 gallons ..	2,500	3·1	4	0	0	15	12	0	200	0	0	
6 Circular mhote	8	12	16 „ ..	4,800	5·4	4	0	0	8	6	0	800	0	0	
7 Persian wheel	15	30	2 „ ..	5,000	6·2	3	8	0	6	8	0	1,200	0	0	
8 Double mhote	20	35	45 „ ..	3,150	3·7	6	0	0	18	8	0	200	0	0	
9 Auto-lift	8	20	5 „ ..	750	0·9	1	2	0	14	10	0	400	0	0	
10 Petrol pump	0	80	....	6,000	7	18	0	0	12	0	0	1,000	0	0	5 h.p.
11 Oil engines	0	120	....	9,000	1	6	0	0	6	10	0	3,000	0	0	7 h.p.
12 Wind mills	15	40	....	500	1·8	0	8	0	3	2	0	1,400	0	0	8 m.h.p.

Plate 187.—*Bullock harness.* P. 1328

Bullock Carts.

It is well known that iron tyred bullock carts do considerable damage to roads and that the friction in the moving parts throws a great strain on the bullocks. To get over these drawbacks, pneumatic tyres with tubes of the heavy duty low pressure type with wheel, hubs and axle fitted with ball-bearing, were obtained from Messrs. Dunlop Rubber Company of India and bodies were built locally at Coimbatore, to serve as farm carts and conveyance vehicles for school children. The pneumatic low pressure tyres provided joltless riding and springs were found unnecessary for the conveyance vehicles.

The weight of the cart was ten cwt. and the effort required to start the cart from rest was 50 lb. and the force required for traction on metalled road was 20 lb. The wear on the tyres was negligible and there was no trouble with the equipment. When the rubber tyre cart was tested on the road with one ton load, the speed of the animals was 2·85 miles per hour, while it was 2·44 miles with the iron tyred cart with the same driver and animals. Even with one and a half tons load on the rubber tyre cart, the animals walked faster than with iron tyred cart carrying one ton load. The only drawback was the heavy initial outlay required for building a rubber tyred cart. Keen cultivators are known to use second-hand bus axles, tyres, etc., and build carts at about the same cost as iron type carts at present. Brakes could be fitted to rubber tyre carts required for use in hilly country, where the roads have often stiff gradients.

Tilting arrangement.—In the ordinary cart, the bullocks have to be unyoked and the carts tilted back for emptying the loads like manure, sand, etc. A new model has been designed at the departmental workshops with the frame hinged on the axle to facilitate the load box being tilted without unyoked the animals. No part of the cart strikes the ground when the box is tilted backwards. When the box is fully loaded and secured, the weight is evenly distributed and the neck of the bullocks is not strained in any way. Attempts are being made to improve the design further and make it extremely appealing to the cultivator.

Miscellaneous Items.

Bullock harness.--The present methods of using bullock power requires a pair of bullocks even for light draughts work, as with five-tyned cultivators. A leather harness has been designed at the departmental workshops for use with single bullocks for field work. The principle of the harness is the same as that used with horses. The point of application of the traction force is the shoulder for horses, while it is the neck just in front of the hump for bullocks. A broad stout piece of leather distributes the tractive force evenly about the neck. Two chain traces transmit the animal's pull to the draw bar of the implement. The harness can be used also for

a pair of bullocks working an implement. One harness is required for each animal and four tracers are connected to the spreader draw bar. But this arrangement is not really necessary for a pair and the ordinary hitching method is equally effective. The single bullock harness is useful for use with light cultivators, and water-lifts with level circular tread like the circular mhote, where a single bullock can do the work satisfactorily.

Yoke designs.—Sore necks are common with bullocks used for field work. The portion of the yoke coming in contact with the neck of the animals was padded with leather and cotton in various ways. The pads tended to slip and bite into the hump especially while turning sharp corners. Padding was unsatisfactory. Leather neck bands provided for the bullocks over which yokes could rest either for road or mhote work, proved satisfactory and prevented sore necks. Harnesses provided for bullocks for hauling four-wheeled trolleys were also satisfactory.

The use of groundnut oil as fuel.—During the war years, crude oil was in short supply for use as fuel for oil engines. Groundnut oil was successfully used in place of mineral oil. The starting of the engine was difficult with groundnut oil and it was found advisable to start the engine on mineral oil and then switch on to groundnut oil. The carbon formed in the vaporiser chamber was harder with groundnut oil and required longer time for cleaning. The vaporiser nozzle tended to get choked and required frequent cleaning. The use of groundnut oil was satisfactory otherwise, but not economical.

The Fal-Kamesam plant.—A plant was erected for forcing preservatives into wood by the Fal-Kamesam process. The chemical preservative used was '*Ascu*' and contained arsenious pentoxide, potassium dichromate and copper sulphate. Hard and soft timbers and bamboo poles were treated with the preservative and sent to different Agricultural Research Stations for testing. Hard wood resisted white-ant attacks better than soft woods, after preservation. The cost of treatment was As. 3–6 per cubic foot of sized timber, and a little more for poles. The cost of treating bamboo poles 12—14 feet long and three to four inches of inner diameter was about As. 1–6 each.

Building construction.—Groundnut storage godown were constructed in 20 selected centres during war years to provide warehouse facilities to cultivators. Steel, cement, teak and cement asbestos sheets were not available and buildings had to be put up with other materials and constructional details had therefore to be suitably modified. Ventilators were provided both at the top and bottom to facilitate aeration of the material that may be stored. A rat-proof ledge was provided all round above the basement level and also collapsible steps, removable at night.

A pilot plant for the manufacture of food yeast from molasses was designed and erected at the Research Institute at Coimbatore. A small-scale commercial plant for the manufacture of malted food and malt extract from sorghum grain was put up at Coimbatore. During the war years import of malt extract was limited and the factory was enlarged to facilitate the manufacture of about 300 lb. of malt extract every day.

Extension service activities.—The import of foodgrains dwindled during the war years and the necessity for increasing the food production in the country was felt. New lands were therefore proposed to be reclaimed with the help of tractors and bull-dozers. War surplus tractors and bull-dozers were acquired and hired out to cultivators for reclaiming new land from 1944–45. There was overwhelming demand for the hiring of tractors and bull-dozers from all over the State and additions were made to the stock of tractors year by year and a large number of tractors are in use in the districts now. The demand is still great and could not be fully satisfied. Here is an opportunity for enterprising men for investing money and doing useful service to the country. Manual and bullock labour are costly and slow for reclamation work and large stretches of land remain to be opened up for cultivation. The demand for tractors and mechanised equipment has come to stay as a permanent feature in the country. A few tractors have already been purchased by individuals in Guntur district and they are being hired out. There is scope for extension to a considerable extent.

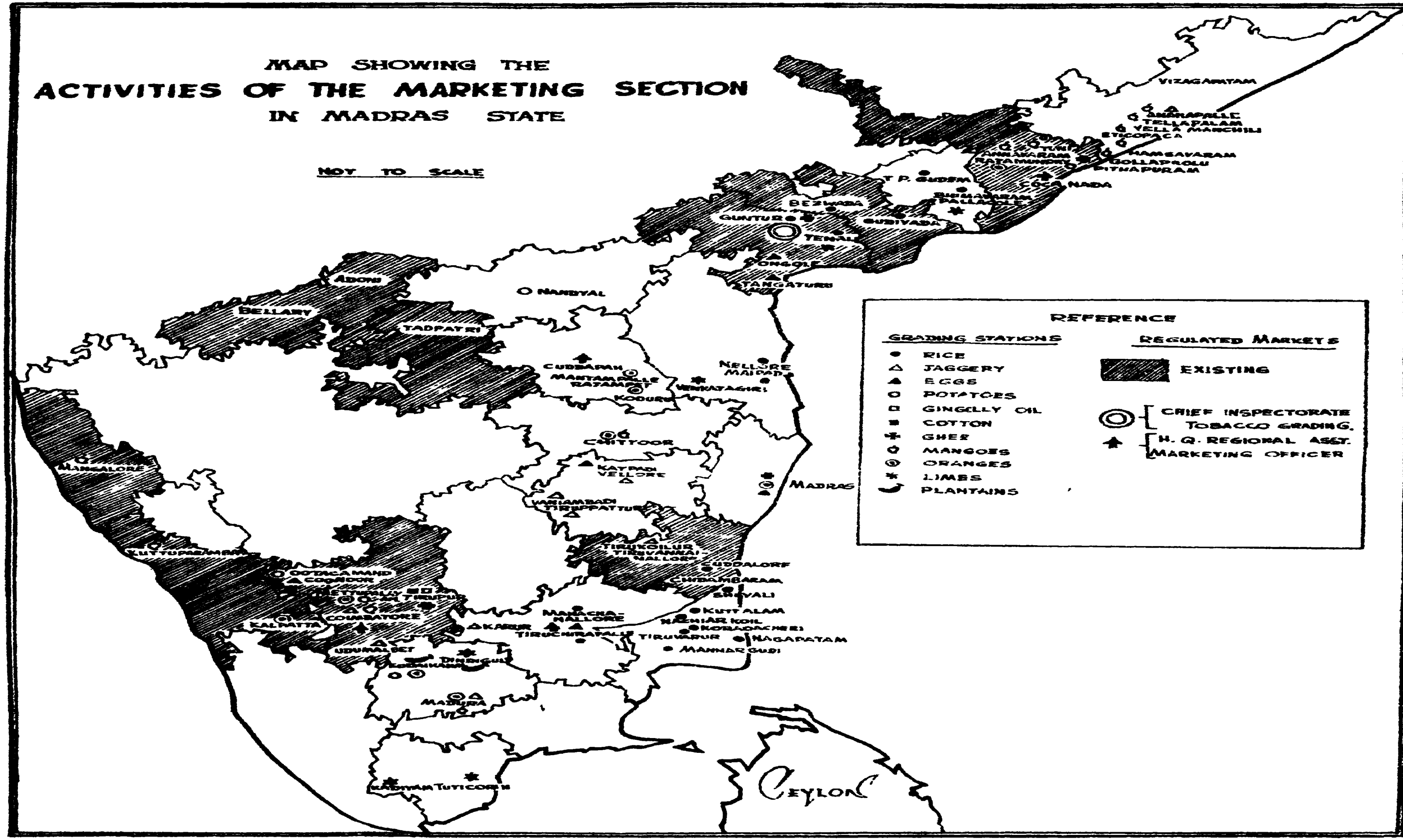
A small skeleton staff of mechanics, foremen and other staff are stationed at the several district headquarters to attend to the servicing of tractors, other mechanised equipment, pump sets, etc. All these are hired out to the cultivators at subsidised rates.

As mechanised equipment and machinery are acquired and put to use, the moving parts get worn out and need periodical renewals. The equipment requires servicing and overhaul once in a way. Two workshops suitable for the purpose have been erected at Coimbatore and Bapatla. It is proposed to extend the range of usefulness of these workshops in course of time and manufacture spare parts for tractors, bull-dozers and other agricultural machinery.

Pump sets, pipes, fittings, etc.—Three hydro-electric projects connected by a grid and a few thermal stations generate electricity in this State. Electric power is generously supplied for agricultural purposes. Taking advantage of this, a large number of electric pump sets have been installed for lifting water from wells for purposes of irrigation, particularly in the central districts. The district engineering staff give technical advice to prospective users, provide information about availability and choice of motors, pumps, pipes, fittings, etc., and help in erection work. In places where electric lines are not running, petrol and oil engine pump sets are advised

to be put up, wherever sufficent supply of water is available in the wells.

The demand for pump sets, tractors, bull-dozers and agricultural machinery has now developed in the country to such an extent that the supplies coming in are not able to meet the demand in full. The chief reason for the development of this heavy demand is the scarcity and high cost of manual and bullock labour. It is just this factor that has helped mechanization of agriculture in western countries and it has started operating here in an inexorable fashion. But the size of the holdings is limited in this country and complete mechanization of agriculture may not be possible here as in other countries. There is however the possibility of limited concerns taking up the work of owning and hiring out agricultural machinery to small cultivators, as is happening in parts of America, in regions where small farmers are found in large numbers.



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CHAPTER 29.

AGRICULTURAL MARKETING.

The need for and the genesis of the marketing section—The several items of work covered—Market surveys and reports of agricultural produce—Fixation of quality standards—Research on containers, transport and processing equipment—Regulated markets and market committees for cotton, groundnut and tobacco—Grading and standardization, tobacco, oranges, potatoes, ghee, jaggery, gingelly oil, rice—Ghee grading laboratories—Market legislation—Market intelligence—Transport, concessional rates and facilities arranged for perishable produce—Help rendered to co-operative societies—The 'AgMark' Act—Work done for 'Grow More Food' Campaign—Miscellaneous items of work—Statement showing grade standards for rice, eggs, oranges, virginia tobacco and paddy varieties —value of produce graded under the 'AgMark' Act.

Introductory.—Till recently, research in agriculture was mainly confined towards crop improvements such as introduction of improved strains, increased yield per acre, manuring and remedies against pests and diseases. The business aspect of marketing with a view to improve the condition of the grower, as well as the country, received attention of the Agricultural departments in India only after the report of the Royal Commission on Agriculture in 1928. The Royal Commission on Agriculture, the Banking Enquiry Committee and the Provincial Economic Conference of 1934, suggested an intensive programme to develop the marketing facilities for agricultural products including crop and livestock products. The Government of India organized from 1934 a Central Marketing staff for the purpose under the control of the Agricultural Marketing Adviser to the Government of India. About the same time, the Madras Government appointed a Provincial (now State) Marketing Officer at Madras from 12th July 1934 and three Assistant Marketing Officers in February 1935, under a scheme financed partly by the Indian Council of Agricultural Research on an all-India basis.

The main objects of the marketing section were—

(1) conduct of market surveys,

(2) working out costs and ascertaining economic condition with a view to get the best value for the producer,

(3) acting as a bureau of market intelligence regarding prices, demand, availability, etc., to producers and Government.

(4) helping the agriculturists to standardise and regulate marketing charges and establishing regulated markets and associating the work with schemes initiated by the Central Government for fixation of basic and fair prices for agricultural produce,

(5) finding out markets for local produce in internal and international trade,

(6) fixation of standards of quality for internal and foreign trade, and

(7) helping schemes of co-operative marketing.

The extent to which the above purposes have been covered by the marketing organisation is detailed below.

MARKET RESEARCH.

(i) *Market surveys.*—The first line of the marketing programme was an intensive study of the marketing of each commodity from the producer to the consumer giving details of prices, production and utilization, conditions of transport, internal and international trade, methods of processing and storage, and the distribution, prices and margins in the several agencies. A consolidated report for India was published on the above basis for each commodity by the Government of India giving recommendations for the improvement of marketing from the field on to the consumer. Similar reports were also prepared for the Madras State. The following market survey reports have been so far published or issued :—

PROGRESS OF MARKET SURVEY (RESEARCH) REPORTS.

Group.	*Published by Government of India.*	*Revised and published by Government of Madras.*	*Revised and prepared for publication by the State Marketing Officer.*	*New survey reports completed for Madras for which All-India reports are being prepared.*
(1)	(2)	(3)	(4)	(5)
Cereals ..	Rice, wheat barley, and maize.	Wheat.	Rice, Barley and Maize.	Millets.
Pulses ..	Bengalgram	..	Bengalgram ..	Pulses.
Oilseeds ..	Groundnuts, castor, linseed, rape and mustard, coconut.	..	Groundnuts, castor and linseed.	Niger, safflower, pungam and iluppai.
Livestock products.	Hides, skins, eggs, cattle, ghee and butter, sheep, goats, wool and hair, milk and fish.	Eggs ..	Hides, skins, cattle, ghee and butter, sheep and goats, wool and hair, milk and fish.	Animal fats and by-products and meat.
Fruits ..	Citrus fruits, bananas, pineapples and grapes.	..	Citrus fruits, bananas, pineapples and grapes.	Mangoes and dry fruits.
Special crops.	Tobacco, potatoes, sugar and sugarcane, cashewnut, coffee, arecanuts and lac.	Tobacco.	Sugar and sugarcane, cashewnuts, potatoes, coffee and lac.	Pepper, ginger, chillies, fibres and betel leaves.
General ..	Markets and fairs, and co-operative marketing.	..	Markets and fairs, co-opertive marketing.	..

Besides the above reports prepared on an all-India basis in co-operation with the Agricultural Marketing Adviser to the Government of India, the following special marketing reports were prepared under the orders of the Madras Government :—

(1) Baskets and rattan work.
(2) Avaram bark.
(3) Bones.
(4) Horn and hoof meal.
(5) Pith.
(6) Coir.

Material for market survey reports has also been collected for the following commodities, viz., neem seed, honey and bees wax, melons and water melons, vegetables and canned fruits.

During the year 1949 Government ordered the preparation of the marketing surveys of minor oil seeds for which special staff was sanctioned through funds got from the Indian Oilseeds Committee and another survey of the marketing of cotton sanctioned with the aid of funds from the Indian Central Cotton Committee. These surveys have been completed.

During the year 1945 the following market survey reports were prepared for the Civil Supplies department under orders of Government for use of the defence services :—

(1) Poultry and eggs.
(2) Beef cattle.
(3) Sheep and goats.
(4) European vegetables.
(5) Fresh foods and necessary commodities.

(ii) *Research on fixation of quality standards.*—Marketing has to be done according to sorts and grades suited to different industrial requirements, so that quick and smooth transactions are effected. Besides, the consumer has to be supplied with genuine produce of guaranteed quality and purity. Grade specifications for quality helps marketing considerably for both the producers and the consumers. Hence, in this connection. several samples of agricultural and livestock commodities were collected from the trade and producers, for analysis and fixation of standards. Based on these, specifications were drawn up so far for the marketable grades under the Agricultural Produce (Grading and Marketing) Act, 1937, through the Agricultural Marketing Adviser to the Government of India for the following commodities important for the country :—

Rice.
Tobacco.
Eggs.
Ghee.
Hides.
Fruit products.
Oranges (Sathukudi).
Mangoes.
Grapes.
Lime fruits.
Groundnut oil.
Gingelly oil.
Castor oil.
Coconut oil (under notification).
Cotton.
Potatoes.
Sunnhemp.
Jaggery.

In fixing grade standards for each commodity, the important commercial quality factors were taken into consideration. Thus, oranges, mangoes and eggs were graded according to size, and rice according to variety and presence of refractions as brokens, foreign matter, other varieties, etc. For cigarette tobacco, the grading scheme took into consideration such factors as colour of leaf, body, size, blemishes, etc. For ghee, grade standards were fixed according to physical, chemical, analysis, the most important factor being the Reichret Meissel value. Instances of such grade standards drawn up are given for rice, eggs, oranges and tobacco in Appendix Tables I to IV.

To help the scheme of purchases of rice and paddy by the Civil Supplies Department, standard specifications for rice and later for paddy were drawn up and these are adopted in the civil supply scheme for fixation of prices and for rejection or imposition of cuts according to deviation from the standard quality. A comprehensive classification of all varieties of rice in different districts was also drawn up (Table V).

(iii) *Research on containers and processing equipment.*—With a view to develop the mechanical grading of oranges, trials were made with different designs of graders and a suitable machine for grading Sathugudi oranges was devised in co-operation with the Research Engineer and the Fruit Specialist, and this is being used for commercial grading work. A compact mechanical grader for lime fruits has been evolved by the Research Engineer, and a gliding grader for eggs recently introduced by him is now under trial.

On the suggestion of the Provincial (now State) Marketing Officer, an insulated van was attached in 1939 to the Malabar Express for carriage of fish from the West Coast areas to Madras, for trial. It was found that the fish carried in the van kept in a better condition, while there was also saving in the quantity of ice required for packing fresh fish. Experiments were conducted, in co-operation with the Fruit Specialist and the Bio-Chemist, Kodur, on the sugar acid ratio of Sathugudi oranges with a view to investigate its possibilities for grading. It was found that the sugar acid ratio increased more or less uniformly from the commencement of the season in September to the end in February and the fruits became sweeter as the season advanced. There was however, not much possibility of grading the fruits according to sugar content as the variations in different lots were more or less of not much account in the same period.

Investigations were made on the sampling methods of rice and groundnuts and a suitable method developed and is being used in standard contracts for these commodities.

DEVELOPMENT WORK.

Based on the results of the research and survey work many recommendations were made to improve marketing in India as well as in Madras by the Governments concerned. The following gives a summary of such development work carried out :—

Regulated markets.—With a view to provide an open market for commercial crops for the growers and the trade where fair sales could be effected under regulated conditions, the Madras Commercial Crops Market Act was enacted during the year 1933. Such regulated markets for cotton functioned very successfully from the point of view of the grower as well as the consumers, in Berar and Bombay. The object of the Act was to establish markets in important areas for the commercial crops through market committees established for the purpose in notified areas. Their functions were to open market yard or yards in the notified areas regulate market charges and market practices, abolish malpractices, check weights and weighments, supply market information and where necessary conduct auctions, standardise contracts and fix standards of quality. With the experience gained to provide for efficient work, the Act was amended recently in March 1949. The market committees are constituted from representatives of the growers and the trade, who are elected from the respective constituencies. The District Agricultural Officer has recently been made ex-officio member and Government may also appoint additional members to the committee or nominate all members in the first year, or under special circumstances.

The Act was first applied in the Tiruppur municipal areas in 1936. During the year 1939, it was extended for cotton in Nandyal and Adoni municipal areas, tobacco in Guntur district and Vijayavada taluk and groundnuts in South Arcot district. The work of the committees was reviewed in 1945 and a separate Agricultural Produce Marketing Bill was considered to provide for efficient regulation of all agricultural commodities. It was finally decided that the Madras Commercial Crops Market Act conferred real benefits on the growers and that its scope should be extended to other areas and crops. The Act was finally amended with the above purpose in 1949.

The main amendments to the Act were the extension of its scope to commodities other than cotton, tobacco and groundnut and the inclusion of such crops as the Government may notify for the purpose. The Act can thus apply to all agricultural produce. Under this provision, the Act was notified during 1949, for coconut and arecanut in Malabar and South Kanara districts and for coconut and tobacco in East Godavari district. The scope of the Act could also be extended to more than one district. Further the jurisdictions of some of the existing committees which had a small area, were later notified to be extended; as for example the Adoni Committee for the whole of the Bellary district and Tirupur Committee for the whole of Coimbatore. A new committee has

been notified in 1949 for cotton and groundnuts in Anantapur district, while the scope of the Nandyal and Adoni Cotton Committees and of the Bezwada Tobacco Committee were extended to groundnuts also, and recently for the whole of the Krishna district.

Administratively, some changes were made to improve the working. The Secretary was made the Executive Officer, while a set of financial rules were also prepared. In the earlier years, the Government granted funds half as loan and half as subsidy, to some market committees to erect offices and godowns. In recent years, loans are being given at cheap rates of interest and recouped over a long period. Co-operative societies are exempted from payment of fees for a licence to purchase. The Government have power to restrict purchase and sale to any prescribed distance from the market yard or to the yard of the committee only.

Grading and Standardisation.

With a view to standardise the quality of agricultural produce in internal and international trade, the Government of India passed legislation called the Agricultural Produce Grading and Marking Act, 1937. According to this Act, the grading of commodities was undertaken as a voluntary measure by persons authorised to do so by the Agricultural Marketing Adviser to the Government of India on the recommendation of the State Marketing Officers. These authorised packers undertake to grade such commodity under the specification laid down by the Act, and the grading is supervised by the marketing organisation. Each package bears the quality. grade specification and date of marking of the commodity graded and should conform to the specification drawn up. The 'Agmark' labels issued by the Government of India are affixed to the graded produce to signify the genuineness of the produce according to grade specifications. The authorised packers, who may be growers, co-operative societies or the trade, send periodical returns of the quantity graded, and any misgrading or failure to comply with the rules is punished with the cancellation of authorisation or other suitable steps.

In Madras, grading was started with cigarette tobacco from the year 1938 and later extended to rice, eggs, Sathugudi oranges, potatoes, jaggery, ghee and gingelly oil. The progress of grading with different commodities is summarised below:—

Rice grading commenced during 1938–39 for the important varieties in Tanjore and Nellore districts. The total quantity graded up to 1945–46 amounted to 897,000 railway maunds valued at Rs. 62 lakhs. The grading of rice was stopped during the period of war when Government took over procurement and distribution of supply on a large scale.

The grading of potatoes which accounted for 78,000 maunds valued at Rs. 327,000 in the Nilgris was also stopped during the war

but has been revived recently. Grading of Sathugudi oranges accounted from five to ten lakhs of fruits every year and was carried out by Koduru Fruit Growers' Co-operative Society. The total graded up to 1948–49 was 81 lakhs of fruits valued at Rs. 9 lakhs. In the same period 182 lakhs of eggs valued at Rs. 15 lakhs were accounted for in Madras City, Katpadi and Ootacamund. Grading of cigarette tobacco was taken up as a voluntary measure from the year 1938, through an organisation of the trade at Guntur called the Indian Tobacco Association. From the year 1943, the Government of India ordered that the entire tobacco exported on consignment abroad from India should bear the 'Agmark' grade specifications under the Sea Customs Act. This gave an impetus to the grading work and a special inspectorate staff was appointed by the Government of India to inspect the quality. From 1945–46, the quantity graded ranged from 40 to 50 million pounds of cigarette tobacco annually and reached a peak of 88 million pounds during 1949–50. The original scheme started with five grades for flue-cured virginia, five grades for sun-cured country and three grades for sun-cured virginia. Now there are 25 grades covering all classifications including stems and jetty tobacco.

The above system of export of tobacco under guaranteed grades has created a good reputation for the quality of Indian tobacco in export markets, and favourable reports have been received from foreign importers.

Although efforts have been made to start ghee grading in Madras, there are technical difficulties in fixing suitable standard specifications. Samples of pure ghee were prepared by the marketing staff for analysis at laboratories at Kanpur, Madras and Bangalore. Finally the Government approved of the fixation of a minimum Reichert Meissel Value of 28 for pure ghee under the Prevention of Food Adulteration Act. For ghee grading, a laboratory is set up by each authorised packer under specifications approved by the Agricultural Marketing Organisation and a chemist appointed for each laboratory to work under the marketing organisation to analyse ghee and mark it according to specifications. The work was started from 1949 in Madras and so far five ghee grading stations have been established at Gollaprolu (East Godavari), Tirupur (Coimbatore), Guntur (Guntur) and Madras City, while another at Tirupur has been completed. So far about 7,300 railway maunds of ghee valued at Rs. 12·4 lakhs have been graded.

A grading laboratory was also erected at Tirupur for gingelly oil during 1949 and accounted for 1,300 railway maunds valued at Rs. 56,000.

The value of produce graded by the marketing organisation at Madras from the inception during 1938–39 up to 1949–50 totalled 29·25 crores of rupees. Of this cigarette tobacco accounted for Rs. 27 crores, rice for Rs. 62 lakhs, eggs for Rs. 16 lakhs, oranges,

Rs. 9½ lakhs and ghee Rs. 12½ lakhs. The details are given in Table (VI) of the Appendix.

Market legislation.—Several legislative measures were taken on hand to improve marketing. A comprehensive bill to facilitate the marketing of agricultural and animal husbandry products on the model prepared by the Agricultural Marketing Adviser was submitted to Government as mentioned already and the Madras Commercial Crops Market Act was also amended. In order to standardise contracts, and regulate produce exchange, proposals were made to Government for a Bill to standardize contracts on the lines suggested by the Government of India. A draft Warehouse Bill, for regulation of warehouse, is now before a Select Committee of the Madras Legislature. With a view to guarantee prices to essential crops, improve land management and cultivate more areas towards increased production, a draft Agricultural Bill was prepared for consideration by Government.

The question of standardisation and checking of weights and measures was another important line of marketing work. All weights used in the notified areas of market committees are periodically checked and stamped and weighment made by licensed weighmen. Proposals were made in 1940 for standardisation of Madras weights in the whole State in line with the standards prescribed in the All-India Weights Act, 1939. The question was taken up by Government recently and a legislation called the 'Madras Weights and Measures Act' passed in 1948. The State Marketing Officer was deputed to study the working of the Act in Bombay in November 1949 and proposed a comprehensive set of rules for administering the Act in Madras.

In order to improve marketing from an All-India point of view the Agricultural Marketing Adviser also prepared a number of Bills for consideration of Government. For control of quality in exports, a Bill called Agricultural Produce Exports (Quality Control) Bill, 1946, was suggested.

The control of quality of exports of tobacco and sunnhemp out of India is now exercised under the Sea Customs Act, but the Bill abovementioned provides for fixation of standards and control of quality in a comprehensive manner of tobacco, sunnhemp, hides and skins, oilseeds, vegetable oils, rice, cotton, fruits, lac and myrobolams. A Bill is also under consideration for the regulation of future trading and forward contracts.

Market intelligence.—During 1935, the marketing organisation prepared a comprehensive system of price quotation in the Madras State and the collection of prices of over 35 commodities in important markets was taken up. This work was later entrusted to the Statistical Officer, then working under the Director of Industries and has been recently transferred to the Economic Adviser.

Prices are published in the Gazette for a number of commodities as foodgrains, pulses, oil seeds and oils, tobacco, jaggery, cotton lint and kapas, oilcakes, chillies, potatoes, hides and skins, cattle and fodder. The marketing organisation was also furnishing periodical prices to the Agricultural Marketing Adviser to the Government of India (milch cattle and livestock products), Economic Adviser to the Government of India (livestock products, cotton, arecanuts), Economic Adviser, Madras (all important commodities), All-India Radio (milch cattle), and Madras dailies (fruits). Recently the dissemination of prices outside the State has been taken up by the Economic Adviser to the Government of Madras, and the marketing staff is furnishing information to him. With the reorganisation of the marketing organisation, fortnightly prices of all important commodities are being collected in important centres of the State, as Kakinada, Madras City, Cuddapah, Coimbatore and Tiruchirappalli.

Besides, several enquiries from the growers, the trade and co-operative societies regarding marketing of crops, are being attended to and the parties helped in the disposal of produce through suitable agencies in and outside the State.

Transport.—In order to encourage movements of produce from producing to consuming areas and improve transport conditions proposals were made to the railway administrations, for grant of special reduced rates. The following gives a list of rates sanctioned by the railways, in pre-war years on suggestions of the marketing organisation :—

Special reduced rates sanctioned for mevement of produce.

Commodity.	*From*	*To*	*Remarks.*
(1) Plantains ..	(a) Stations in East Godavari district.	Cities in Northern India.	Reduced rates.
	(b) Stations in Tiruchirappalli area.	Do.	Do.
(2) Lime fruits ..	(a) Venkatagiri, Tenali and Katpadi.	Calcutta ..	Do.
	(b) Stations in North Arcot and Madurai districts.	Stations in West Coast and Coimbatore.	Do.
(3) Pine apples ..	West coast stations.	Bombay, Calcutta	One-third parcel rates instead of ½ parcel.
(4) * Eggs in standard containers.	Producing centres..	Consuming centres.	Do.
(5) * Returned empties for eggs.	Consuming centres.	Producing centres.	One-sixth instead of ¼.
(6) Dry cows and calves.	(a) Madras City ..	Grazing area in Guntur and Nellore.	Terminal charges abolished.
	(b) Grazing area in Guntur.	Madras	Rates reduced by half.

* Arranged by Agricultural Marketing Adviser to the Government of India.

Commodity.	*From*	*To*	*Remarks.*
(7) Ice	Supplying centres..	Fishing areas in West Coast.	Reduced rates.
(8) Limes, oranges, sapotas.	Stations in East Godavari.	Berhampur, Cuttack and Vizianagaram.	Do.
(9) Rice and paddy.	All important areas in Tanjore district.	All stations in West Coast and Travancore.	Do.
(10) Oranges ..	(a) Calicut, Tellicherry.	Any stations in South Indian Railway over 200 miles.	One-third instead of ½ parcel rate.
	(b) Stations in Chittoor and Cuddapah districts.	(i) Any stations in South Indian and Madras and Southern Mahratta Railway over 300 miles.	Do.
		(ii) 400 miles over.	Quarter instead of ½ parcel rate.
(11) Groundnuts ..	Important stations in South Arcot and Tanjore.	Calicut, Cochin ..	Special rate.
(12) Cumblies ..	Hindupur	Shalimar ..	Reduced rates.

Many of the reduced rates above were cancelled by the Railway in the emergency conditions created by the war, but recently efforts are being made to grant similar concession especially for cattle and plantains. The provision of wooden wagons for transport of fruits and attaching them to expresses and fast passenger trains for long distance traffic also received attention. During 1939–40, the South Indian Railway arranged to run a trial insulator van for transport of West Coast fish to Madras and Bangalore.

Many suggestions were made for opening more transport routes for marketing and in particular to the opening of ports at Malpe and Point Calimere and the introduction of new railway routes from Dindigul to Gudalur, Tanjore to Pattukkottai and in the Godavari area from Ellore to Saneri.

HELP RENDERED TO CO-OPERATIVE SOCIETIES.

Co-operative organizations have expanded in recent years in the marketing of agricultural produce and other commodities like eggs, milk, etc., of animal origin. The Government entrusted the work of procuring and distributing of foodgrains in their areas, during and after the war period, in order to encourage them. The marketing section has been actively helping the development of these marketing societies.

At the suggestion of the Registrar of Co-operative Societies and the Marketing Board, proposals were made for expanding the marketing activities of co-operative societies and some of the loan

and sale societies were converted into marketing societies. In addition, special societies for certain crops were also established, namely :—

(1) Kodur Fruit Growers' Co-operative Society.

(2) The Nilgiri Potato Co-operative Marketing Society.

(3) The Co-operative Marketing Societies for Eggs in Katpadi, Ongole, Kaveripatnam.

(4) The Malabar Arecanut Marketing Society, Ponnani.

(5) The Cardamom Co-operative Society, Madura.

The expansion of co-operative marketing of rice in the large producing areas was also discussed with the Registrar. For this purpose, the Tanjore Paddy Marketing Federation was started. Similar federations for paddy now operate in Nellore, Krishna, Guntur, East Godavari and West Godavari districts. A scheme for forming a co-operative society to pool cigarette tobacco and work a redrying plant was also considered along with the Government of India and the Registrar of Co-operative Societies. It was decided that the redrying plant ordered by the Indian Tobacco Committee may be worked by the Committee itself. Special investigations were made by the marketing staff for the improvement of co-operative marketing for coconuts in East and West Godavari districts, for cardamoms in Madurai district, potatoes in the Nilgiris, paddy in Tanjore and proposals made for better marketing to the Marketing Board. In addition, help was rendered to co-operative societies for supply of information regarding prices, market conditions and addresses of merchants for disposal of produce. A special society at Madras, called the Provincial Co-operative Marketing Society was organised by the Registrar of Co-operative Societies in Madras during 1936, for co-ordinating the work and marketing activities of the loan and sale societies and the State Marketing Officer helped in the work as an ex-officio Director. During the war period this society was entrusted with the marketing and distribution of certain controlled commodities.

Besides the above work, help was also rendered to co-operative societies for grading and marketing commodities under the 'Agmark' Act. The following gives a list of co-operative societies that were authorised to do grading work and the value of commodities graded :—

Commodity.	*Names of authorized co-operative societies.*	*Value of produce graded up to 1949–50.*
		RS.
(1) Oranges ..	Kodur Fruit Growers' Society and Provincial Co-operative Marketing Society.	9,57,200
(2) Eggs	Societies at Ongole, Katpadi, Kaveripatnam and Madras.	2,71,300
(3) Rice	Maipad Loan and Sale Society, Nellore district.	1,01,000
(4) Potatoes ..	Nilgiri Potato Marketing Society	3,96,300
(5) Limes ..	Societies at Palakol, Kadayam	25,900
	Total ..	17,46,700

Produce worth nearly Rs. 17½ lakhs were graded so far by co-operative organisations in Madras under the 'Agmark' scheme.

Work done for the "Grow More Food" and controls by the Civil Supplies.—Help was given in connexion with various measures taken by Government in order to conserve essential supplies for the Defence Services and Civil population during the war. Proposals were made for the fixation of ceiling prices of paddy and rice, cotton and cotton seed, sugar and sugarcane, potatoes, beef and mutton. Zonal schemes for the distribution of cotton seed and jaggery were drawn up. For maximisation of production of food crops, targets for increased production were drawn up for each year in different districts. About 300 tons of potatoes were purchased for the Defence Services. With a view to control the prices and secure distribution of jaggery, an Assistant Marketing Officer was appointed in 1943 and about 21,000 tons of jaggery were exported to other States. The Provincial (now State) Marketing Officer was a member of the Provincial sub-committee of the Co-ordinating Committee of Food Stuffs, and helped in the arrangements for procurement and supply of essential articles for the army. As already mentioned, a special rapid survey of poultry, eggs, beef, cattle, sheep and goats, European vegetables and fresh foods and necessary commodities was made for the use of the Defence Services. Two Assistant Marketing Officers were deputed to work under the Civil Supplies Department in Central Provinces, the United Provinces and Punjab, to purchase pulses, cotton seed and some foodgrains. Considerable data were supplied to officers of the Civil Supplies Department and Defence Services in regard to production, prices and sources of supply of essential commodities required during the war.

The Rice Mills Licensing Order and control of quality in rice.—This order was enforced by the Government in the year 1943, to increase the output of rice to paddy by reducing the amount of polish. This Order was revoked in 1949 and a normal single polish was permitted, in view of the numerous complaints that were received against the quality of the dehusked rice. Milling tests were conducted by the marketing staff to determine the percentage of outturn of rice to paddy under different conditions. A monthly return of quantities of paddy milled and rice obtained was got from the rice mills and a review prepared to help the Civil Supplies Department.

The number of rice mills and the quantity of increased output according to the Rice Mills Licensing Order were as follows :—

Year.	*Number of mills.*	*Average percentage increase over normal.* (67 PER CENT.)	*Estimated increased output of rice.* (TONS).
1943–44	4,907	3·7	42,000
1944–45	5,326	2·8	60,600
1945–46	5,713	1·9	41,600
1946–47	6,069	2·9	35,100
1947–48 (11 months)	2,996 (only rationing areas).	3·55	27,300
		Total ..	206,600

During 1948, the milling of rice was ordered to be limited to dehusking only without polish.

It will be seen that the working of the Order has introduced so far a saving in rice to the tune of 206,600 tons valued roughly at 5·4 crores of rupees in five years on 41,320 tons annually. In the earlier years there were complaints regarding quality of unpolished rice. But with experience gained the quality improved.

In order to improve the quality of rice procured and distributed through the Civil Supplies, a system of standard specifications was drawn up, whereby payments were made according to basis of purity and refractions within tolerance and rejection limits. A comprehensive classification of all varieties in each district was drawn up into Special, First, Second and Third sorts for fixing prices of rice. But as this system of classification into several sorts, gave rise to abuses on the part of millers and procurement agents, the Government subsequently ordered the classification of paddy and rice only into two sorts, viz., first and second; the first sort comprising the old special and first sort stocks and the second sort comprising the old second and third sorts. A system of standard specifications for paddy was also drawn up. This system helped generally to improve the standard of quality, while a saving in the output of rice was effected through the working of the Rice Mills Licensing Order. The scheme is still continuing although the monthly returns from mills was stopped from the year 1949. A large number of samples of rice and paddy and foodgrains were analysed and remarks offered regarding quality and fixation of prices.

Work done for heads of departments.—In addition to close touch maintained with the Civil Supplies and Co-operative departments as mentioned above, the marketing organisation also helped in the work of the Animal Husbandry and Industries departments. Besides the special surveys on livestock products, the Director of Animal Husbandry was furnished information from time to time regarding production, imports, exports, prices and marketing of a number of livestock produce as cattle, milk, eggs, ghee, butter, both by correspondence and personal visits. Special market surveys were prepared on fish, basket and rattan, *avaram* bark and coir, on the suggestion of the Director of Industries and Commerce and information was furnished to him on a number of subjects relating to industries, and, in particular, about hides and skins, sugar, oil crushing, tobacco manufacture, fish, vegetable products and cold storage. Notes were also prepared on the expansion of sugar and oil milling industries.

Information was collected on the marketing of practically all important crops and livestock produce, some of which have already been mentioned.

Administration.—In the year 1934, the marketing section started with one Provincial (now State) Marketing Officer and three Assistant Marketing Officers for marketing. A separate Assistant Marketing Officer for development work was sanctioned for three years from 1936, with four Marketing Assistants at Tiruchirappalli, Coimbatore, Rajahmundry and Madras. With the expansion of the work and to provide for a more intimate contact with growers, the Government sanctioned a scheme of reorganisation into regional units in the districts with an Assistant Marketing Officer and one assistant in each, at Kakinada, Tiruchirappalli, Cuddapah and Coimbatore.

Statement No. I—*Grade Standards for rices of the Madras State.*

STATEMENT No. I—*Grade standards*

Maximum limits of tolerance

Name of variety. (1)	*Grade designation.* (2)	*Foreign matter.* (3)	*Broken grains.* (4)	*Fragments.* (5)	*Other rices.* (6)	*Damaged or discoloured.* (7)	*Weevilled grains.* (8)		
White Sirumani (boiled).	Special.	Trace.	4·0	Nil.	1·0	0·25	Reasonably free.		
	A	0·25	5 0	1·0	2·0	1·0	Do.		
	B	0·25	10·0	1·0	2·0	1·0	Do.		
White Sirumani (raw).	Special.	Trace.	12·0	1·0	1·0	1·0	Do.		
	A	0·25	20·0	2·0	1 75	2·0	Do.		
	B	0·50	25·0	3·0	2·50	3·0	Do.		
Red Sirumani (par-boiled).	Special.	Trace.	3·0	Nil.	1·0	0·25	Do.		
	A	0 25	5·0	1·0	2·0	1 0	Do.		
	B	0·25	10 0	1·0	2·0	1·0	Do.		
Nellore samba (boiled).	Special.	Trace.	4·0	1·0	1·0	Trace.	Do.		
	A	0·25	8·0	2·0	1·75	0·5	Do.		
	B	0 50	12·0	3·0	2·50	1·0	Do.		
Nellore samba (raw).	Special.	Trace.	10 0	2·0	2·0	0·5	Do.		
	A	0 5	15·0	3 0	4·0	1·0	Do.		
	B	1·0	20 0	5·0	6·0	2·0	Do.		
Molagolukulu (raw) ..	Special.	Trace.	7 0	1 0	1·0	0·5	Do.		
	A	0·5	12·0	1·5	1·5	1·0	Do.		
	B	0·5	20·0	1·5	1·5	1·0	Do.		
Molagolukulu (hand-pounded).	A	1·0	15·0	1·5	1·5	1·0	Do.		
Korangu or Arai Samba or Kattai Samba.	Special.	Trace.	4·0	1·0	2·0	1·0	Do.		
	A	0·25	8·0	2·0	4·25	1·5	Do.		
	B	0·50	12·0	3·0	6·50	2·0	Do.		
Delhi Bogham or Vankisannam.	Special.	Trace.	6 0	2·0	1·0	Free.	Do.		
	A	0·5	12 0	3·0	2·0	0 5	Do.		
	B	1 0	18 0	4 0	3 0	1·0	Trace	..	..
G.E.B. 24 or Kichili ..	Special.	Trace.	6·0	2 0	1·0	Trace.	Reasonably free.		
	A	0·5	12 0	3·0	2·0	0·5	Do.		
	B	1·0	18·0	4·0	3·0	1·0	Trace	..	..
Krishnakatukulu or Akkusannam or Maharajabogam.	Special.	Trace.	5·0	2·0	2·0	0·5	Do.	..	..
	A	0·25	10·0	3·0	2·5	1·0	Do.	..	..
	B	0·50	15·0	4·0	3·0	1·5	Do.	..	..
Bangarutheeka or Kasipichodi.	Special.	Trace.	6·0	3·0	3·0	Trace.	Do.	..	..
	A	0·50	9·0	4·5	6·5	Do.	Do.	..	..
Atragada or Ramsagar.	Special.	Trace.	11·0	3·0	1·0	Free.	Reasonably free.		
	A	0·5	17·0	5·0	2·0	0·5	Do.		
	B	1·0	23·0	7·0	3·0	1·0	Trace	..	..
Kusuma	Special.	Trace.	11·0	3·0	1·0	Free.	Free	..	..
	A	0·5	17·0	5·0	2·0	0·5	Trace	..	..
	B	1·0	23·0	7·0	3·0	1·0	Do.	..	..

for rices of the Madras State.

percentage.			*Size of grain.*			
Chalky grains.	*Total.*	*Weight of 1,000 grains grammes.*	*Length mm.*	*Breadth mm.*	*Remarks.*	*District of origin.*
(9)	(10)	(11)	(12)	(13)	(14)	(15)
Nil.	4·5	11 5 to 12·0	3·7—3·9	2·3—2·5	Small round grains.	Tanjore.
Nil.	10·0	Do.	Do.	Do.	Do.	South Arcot.
Nil.	15·0	Do.	Do.	Do.	Do.	....
1·0	16·0	11·5 to 12·5	3·7—4·3	2·3—2·8	Uniform in size ..	Tanjore.
2·0	28·0	Do.	Do.	Do.	Do. ..	South Arcot.
3·0	37·0	Do.	Do.	Do.	Do. ..	....
Nil.	4·5	15·0 to 15·5	4·2—5·5	2·4—2·7	Small round grains.	Tanjore.
Nil.	10·0	Do.	Do.	Do.	Do.	South Arcot.
Nil.	15·0	Do.	Do.	Do.	Do.	....
1·0	7 0	15 5 to 16·5	5·12—5·6	2·3—2 6	....	Tanjore.
1·5	14·0	Do.	Do.	Do.	....	Tiruchirappalli.
2·0	21·0	Do.	Do.	Do.	....	....
2·0	16·5	14·5 to 16·0	5·2 —5 6	2 3—2·5	....	Tanjore.
4·0	27·5	Do.	Do.	Do.	....	Tiruchirappalli.
6 0	40·0	Do.	Do.	Do.	....	....
1·5	9·5	15·5 to 16·0	5 2—5 3	2 3—2 4	....	Nellore.
3·5	19 0	Do.	Do.	Do.	....	....
5·5	31·0	Do.	Do.	Do.	....	....
4·0	25 0	15 5 to 16·0	5 2—5 3	2 3—2·4	....	Nellore.
Chalky.	8·0	16·4 to 17·4	4 8—5 3	2 3—2 6	Abdominal white in commercially accepted proportion.	Tiruchirappalli.
Do.	16·0	Do.	Do.	Do.	Do.	Tanjore.
Do.	24·0	Do.	Do.	Do.	Do.	....
Slightly chalky.	9·0	14·0 to 15·0	5·5—6 0	1 9—2 2	....	Krishna.
Do.	18·0	Do.	Do.	Do.	....	Guntur.
Do.	27·0	Do.	Do.	Do.	....	....
Slightly chalky.	9·0	12·5 to 13·75	5·2—5·7	2·0—2·3	Slightly chalky ..	Krishna.
Do.	18 0	Do.	Do.	Do.	Do. ..	Guntur also.
Do.	27·0	Do.	Do.	Do.	Do. ..	West Godavari.
0·5	10·0	13·0 to 14 0	5·3—5·4	2 0—2·2	White	East and West Godavari.
1·0	17·75	Do.	Do.	Do.	....	....
1·0	25·0	Do.	Do.	Do.	....	....
1·5	14·0	9·2 to 10·0	5·5—6·0	1·5—1·6	White to chalky.	East and West Godavari.
2·5	23·5	Do.	Do.	Do.	Do.	....
..	15·0	17·2 to 18·2	5·5—6·0	2 2—2·5	White to chalky opaque.	Krishna and Guntur.
..	20·0	Do.	Do.	Do.	Do.	....
..	35·0	Do.	Do.	Do.	Do.	....
Chalky.	15·0	18·0 to 19·0	5 8—6 3	2·2—2·5	White to chalky opaque.	Krishna and Guntur.
Do.	25·0	Do.	Do.	Do.	Do.	....
Do.	35·0	Do.	Do.	Do.	Do.	....

STATEMENT II.—*Grade designation and definition of quality of eggs (hen and duck) produced in India.*

Grade designation.	*Definition of quality.*			
	Hen's eggs.		*Duck's eggs.*	
	*Minimum weight.**	*State or condition.*	*Minimum weight.**	*State or condition.*
	OZ.		OZ.	
Special ..	2	The eggs must not have been preserved by any process and must be free from taint; the shell must be clean and free from stain, sound, of normal texture and shape. The contents must be free from blemish, the yolk central and translucent or faintly but not clearly outlined and freely mobile, the white must be translucent and clear, and the air space must not exceed three-eighths of an inch in depth.	2¼	The eggs must not have been preserved by any process and the shell must be clean, free from stain and sound, the yolk central, visible but not dense, and freely mobile. The white must be translucent, firm and not watery.
A	1¾		2	
B	1½		1¾	
C	1		1½	

* To allow for accidental errors in grading a tolerance of one drachm in the weight of any egg may be permitted.

STATEMENT III.—*Grade designations and definition of quality of oranges (tight skinned) produced in India.*

Sathgudi Type.

Grade designation.	*Minimum diameter.**	*Definition of quality—State or condition.*†
	INCHES.	
Extra Special.	3½	(1) The oranges shall be firm and shall have reached a stage of maturity which will permit the subsequent completion of ripening in the ordinary course of transport and marketing without appreciable loss of firmness. (2) The oranges shall be of reasonably uniform colour. No orange shall be entirely green. (3) Each orange shall have the shape normal to the variety and free from malformations. (4) The oranges shall be free from defects due to diseases or insects or mechanical injury or sunburn affecting the fruit internally. (5) Oranges having a coarse corrugated skin shall not be graded.
Special ..	3¼	
Good	3	
A	2¾	
B	2½	

* Fruits exceeding the diameter given against the Extra Special by ¼ inch shall be excluded. A tolerance of 10 per cent shall be allowed for accidental errors in grading in respect of oranges corresponding with the size specification in the next lower grade.

† In respect of items referred to in column (3), a tolerance of 5 per cent shall be allowed in any one package to cover accidental error in grading except the defects referred to in items (4) and (5) for which no tolerance shall be allowed.

STATEMENT IV.—*Grade designations and definition of quality of unmanufactured flue-cured virginia* tobacco grown in India.*

Grade designations.	*Colour.*†	*Texture.*†	*Body and condition.*
(1)	(2)	(3)	(4)
1	Bright lemon and/or bright orange.	Fine ..	Good body leaves or strips free from sponginess, scalding ,bruising or blemish due to disease.
2	Do.	Good ..	Good body leaves or strips which may have light and occasional spongy or brown spots or blemish due to disease, all together not exceeding 5 per cent of the total area.
3	Yellow to light orange.	Medium ..	Good body leaves or strips which may have spongy or brown spots or blemish due to disease, all together not exceeding 10 per cent of the total area.
4 .. .	Do.	Do. ..	Good body leaves or strips which may have spongy or brown blemish due to disease, all together not exceeding 25 per cent of the total area.
LG ..	Light green coloury.	Do. ..	Good body leaves or strips with light greenish cast which may have spongy or brown spots or blemish due to disease, all together not exceeding 10 per cent of the total area.
LMG ..	Light medium green.	Medium to course.	Good body leaves or strips with greenish cast which may have spongy, scalded or brown spots or blemish due to disease, all together not exceeding 25 per cent of the total area.
DG ..	Dark green ..	Variable ..	Good body leaves or strips of heavy green character not falling within LG or LMG.
LBY ..	Light brownish yellow.	Fair body or mixed.	Good body leaves or strips which may have brown-patches, spongy, scalded or bruised spots or blemish due to disease, all together not exceeding 25 per cent of the total area.
LBY_2 ..	Do.	Do.	Good body leaves or strips which may have brown patches, spongy, scalded or blemish due to disease not exceeding 50 per cent of the total area.

Statement IV.—*Grade designations and definition of quality of unmanufactured flue-cured virginia* * *tobacco grown in India*—cont.

Grade designation. (1)	*Colour.*† (2)	*Texture.*† (3)	*Body and condition.* (4)
B ..	.. Brown	Fair body or mixed.	Good body leaves or strips which may have brown patches, spongy, scalded or bruised spots or blemish due to disease ; all together not exceeding 40 per cent of the total area.
DB ..	Dark brown ..	Do.	Good body leaves or strips which may have brown patches, spongy, scalded or bruised spots or blemish due to disease not exceeding 40 per cent of the total area.
BB ..	Bright lemon or bright orange or yellow to light orange or mixed.	Do.	Broken pieces (not less than three inches long) of leaves of grades 1 to 4.
BB [2] ..	Light brownish yellow or brown or mixed.	Do.	Broken pieces (not less than three inches long) of leaves of grades LBY, LBY [2] and B.
BB [3] ..	Light green or light medium green or mixed.	Medium to coarse.	Broken pieces (not less than three inches long) of leaves of grades LG and LMG.
PL	Mixed	Variable ..	Perished leaf.
X‡	....	..	....
FS§ ..	Bright lemon or bright orange or yellow to light orange or light brownish yellow or brown or mixed.	Fair body or mixed.	Broken pieces (not less than one inch long) of leaves of all grades excepting green.
FS [2] mixed.‖	....	Variable ..	Broken pieces of less than 1 inch in length and free from dust and extraneous matter.
Stems ¶ ..	....	....	Stems shall consist of midribs leaves removed to the extent of at least one-half length of the leaf in the process of stemming from Virginia varieties of tobacco and their hybrids.

* Virginia tobacco shall consist of Virginia tobacco varieties and their hybrids having similar characteristics.

† To allow for accidental errors in grading, a tolerance of 5 per cent of leaves or strips corresponding to the specifications of the next lower grade will be allowed in all cases.

Note.—Grades 1, 2, 3, 4, LG and BB are considered to be tobaccos of distint Bright or Coloury cigarette character.

‡ Grade designation will be applicable under the following conditions :—

(1) That the sale is against a firm order, the phrase "firm order" being defined to mean either that the whole of the purchase money is to be paid in cash beforehand or is guaranteed in some other way.

(2) That the consignment is sold to a recognized manufacturer, according to specifications and blends which are not covered by the grade designations and definitions of quality laid down in the schedule. If the order is placed by a broker on behalf of a manufacturer/manufacturers evidence should be produced to prove that the whole of the consignment is meant for use of the manufacturer/manufacturers concerned. A recognized manufacturer shall mean a manufacturer of tobacco products or by-products recognized by the Agricultural Marketing Adviser to the Government of India as such.

(3) That this will be confined to sales to manufacturers in the United Kingdom and not extended to any other importing country or to sales within India.

(4) The tobacco marked under 'X' grade shall not be sold in the market. But in exceptional cases where the manufacturer does not accept the consignment of 'X' grade tobacco intended for him, the authorized packer concerned shall produce satisfactory evidence to that effect to the Agricultural Marketing Adviser to the Government of India or to any officer authorized by him in this behalf who may permit the authorised packers to sell such tobacco in the open market.

§ The grade designation shall be applicable only under the following conditions :—

(1) That the sale is against a firm order from buyers, the phrase 'firm order' meaning that either the whole of the purchase money is to be paid in advance in cash or is guaranteed in some other way.

(2) That the grade designation shall be affixed only when the packing is done at the specified premises of packers authorized to grade and mark flue-cured Virginia tobacco under the supervision of the Tobacco Inspectorate staff.

‖ The grade designation shall be applicable only under the following conditions :—

(1) That the sale is against a firm order from buyers the phrase 'firm order' meaning that either the whole of the purchase money is to be paid in advance in cash or is guaranteed in some other way.

(2) That the grade designation shall be affixed only when the packing is done at the specified premises of packers authorized to grade and mark flue-cured Virginia tobacco under the supervision of the Tobacco Inspectorate.

(3) That the grade designation shall be affixed only when the tobacco is meant for any purpose other than cigarette and pipe tobacco manufacture.

¶ Grade designation will be applicable under the following conditions :—

(1) That the consignment is meant for export against a firm order from buyers from foreign countries other than the United Kingdom, the phrase 'firm order' being defined to mean either that the whole of the purchase money is to be paid in cash before hand or is guaranteed in some other way.

(2) That the packing is done at the authorized premises under the supervision of the Tobacco Inspectorate staff.

STATEMENT V.—*Statement showing the classificatoin of various paddy varieties for Civil Supplies procurement in Madras by each district.*

(Civil Supplies Department Classification.)

Special sort. (1)	*First sort.* (2)	*Second sort.* (3)	*Third sort.* (4)
I. *Chittoor.*			
GEB or Kichili samba, Raja samba and Kasi Pichodi.	Chinna samba, *Jadamalagolukulu* or Co. 15, Sirumani or Co. 19, Tella Sannavadlu, Poombalai or Co. 2 and Yerra Sannavadlu.	Vadan samba or Co. 17, Pichavadlu, Swarnalu or *Swarnavari*, Swarna samba and Tella Kesari.	Erra Kesari, Gidda karu, Byruvadlu, ADT 9: Poonkar, ADT 3: Kuruvai, Co. 13 and Arupatham kodai.
II. *Chingleput.*			
Molagolukulu of Nellore, GEB 24 or No. 1 or Kichili or Kichidi or *Thuvamalli* Doppi, *Kasi Pichodi* Co. 1 or Peria Kichili or Coimbatore Sannam, Delhi Bhogam or Vanka sannam, Sanna Krishnakatulu, *Jeeraga samba* or *Kamban samba*.	Kothamallisamba, White Sirumani, Red Sirumani, Poon samba, Baya kunda, Chinna samba, Sivan samba and Kodan samba.	Red kar, Vadan samba (*white*), Palan samba, Sembalai, Kappa samba, Vellai kar, *Swarnavari* or Sornavariand all other samba varieties not falling under *special* or first sort.	Kappa kar, Kulla kar, Mannakkathai, Mosanam, Manavari,-Guddakar and *Vadan samba red*.
III. *Tiruchirappalli.*			
Kichili or Kichidi samba or GEB 24 Jeeraga samba.	Nellore samba, Vellai samba and Sada samba.	Arumbavoor kuruvai, Arumbavoor samba, Kalimadayan and Poonkar.	Sarapalli, Kuruvai, Kar, Valan and *Manakathai*.
IV. *Tanjore.*			
Kichili samba or GEB 24 Jeeraga samba and Konakuruvai.	White sirumani or Kothamalli, samba (ADT 2), *White sirumani* (ADT 8), Red Sirumani or Sirumani (ADT 1), Nellore samba (Fine) ADT 11, Patnam samba, Kavinginpoothala (PTB 15), Ratna kuruvai *Poombalai*, Kuruvai Sirumani (ADT 20), *Coimbatore samba or Chingleput sirumani or Co. 19, Garudan samba* Sadai samba.	Thillai samba, Katta samba or Araisamba or Korangu samba or Katta vellai, Nellore samba (Coarse) (ADT 5), White and Red Ottadan, Anandan samba, *Vadan samba, white*, Mottu samba Sandikar, *Aadumulingi*, Sembalai, Raman samba, Poonkar, Alaga vanam, Muthu samba, *Mappillai samba* and *Kandeduthu samba*.	White kuruvai, Red kuruvai, Chitraikar, Sarapalli, Swarnavari, Red kar or Rose kar, Kattuvanam, Karunguruvai Kullakkar, Puthalai, Alugina kar, Mattai samba, Mattai kuruvai, Poombalai and Vadan samba (red).

	V. *Guntur*.		
Molagolukulu GEB 24 or No. 1 or Kichidi, Kasi Pichodi or Bangara Teega Delhi Bhogalu.	Akku sannalu, Chintalapudi sannam.	Kusumma, Konamani, Akkulu and Ramasagaram.	
	VI. *North Arcot*.		
Kichili samba, Thuyamalli, *Nellore Molagolukulu*, Jeeraga samba Kasi Pichodi, Thanga kambi and Bangaru theegalu.	Chinna samba, Poombalai Sirumani Gundu sirumani, Sadai samba, Molagu sirumani and Sathan samba.	Vadan samba, *White*, Sornavari or Swarnavari Vellai kar Kodam samba, Mapasi and Tunaipalai.	Vadan samba (red), Gedda-vari, Pisanam Red kar Manakathai Mosanam and Pisini.
	VII. *Nellore*.		
Molagolukulu (local), Pishanam and Strains (Molagolukulu 2202, 2552, 2555 and 0015 called Pedda Molagolukulu), GEB 24 (Locally called number vadlu or Tenkayaputavari.)	Rail samba (Co 2. Poombalai Co 5. Chinna samba and Co. 7 Sadai samba.	Vadan samba or vada samba, Pedda samba, Mattai samba, Garika sannavari varieties (MTU 9 and MTU 15 Atragada).	Kesari (Tella kesari, Pedda kesari). Pottinallavari, Iswara Kora Metta sambalu.
	VIII. *Krishna*.		
Kichidi or GEB 24, Delhi Bogam *Vanka sannam Bangaru teegalu Sannamikri shnakatukulu*.	K 12 or MTU 19 *or sanna kusuma*.	Akkulu, Garikasannam Konamani, Kusuma, Basangi and Ramasagaram.	Dalwa, Budama, Arelu, *Jilama*.
	IX. *East Godavari*.		
Kichili Sanna Krishnakatakulu, Kasi Pichodi, *Venkasannam, Delhi Bhogam Co.* 1 *or Peria Kichili* and Sanna Bayyahunda.	Bontha Krishna katukulu Farm Konamani Co. 2 or Poombalai.	Akkulu, Konnamani, Gummasari, *Basangi, Basangi*. Cariki or Garikasannam.	Budama and Dalwa.
	X. *West Godavari*.		
Bangara theega or Venka Sannam, GEB 24 or Kichidi, Sanna Krishnakatukulu. Delhi Bhogam Co. 1 or Peria Kichili or *Coimbatore sanna*.	Co. 2. Poombalai, Krishnakatukulu K 12 also called MTU, 19 or Sannakusuma SR 26B.	Akkulu, Basangi, Rasangi, Konamani, Gariki sannam, Punasa and Attragada.	Budama, Dalwa and *Nalla Arolu*.

STATEMENT V.—*Statement showing the classification of various paddy varieties for Civil Supplies procurement in Madras by each district*—cont.

(Civil Supplies Department Classification)—*cont.*

Special sort. (1)	*First sort.* (2)	*Second sort.* (3)	*Third sort.* (4)
	XI. *South Arcot.*		
GEB 24 also called No. 1 Kichili, Kichidi, or *Thuyamalli Kasi Pichodi White* Jeeraga samba, Kamba samba, Co. 1 or Peria Kichili or Coimbatore sannam.	Kothamalli samba or white Sirumani or ADT 2 or ADT 8 Red Sirumani or ADT, of 1 of Chidambaram taluk. White sirumani of Gingee and Kallakurichi taluks. Gundam samba of Villupuram, Tindivanam, Cuddalore and Tirukoilur taluks. Poombalai or thigai samba or Co. 2. PTB. 15 or Kavinginpoothala, Segappu sirumani of Cuddalore taluk. *Red sirumani of Gingee taluk. Sirumani of Tindivanam, Villupuram and Tirukoilur taluks.*	Muthusamba or Paruenel. Nellore samba of Chidambaram taluk. Vadan samba, Sinam samba, Ottadam, Kittan samba, *Nellore samba ADT* 5. *Coarse* (9) Vangusamba and kappa samba of Tirukoilur taluk *Athur samba*, Poovan samba Thillainayam samba, Poonkar, Kullakar and Swarnavari.	Vadan samba-red Kar (all varieties), Kuruvai, Thattan samba, Paryakonda of Tindivanam taluk. Mosanam, Posanam, Mottakuruvai of Tindivanam taluk and Chitrakali.
	Vellai samba, Pattrai samba, Kuruvari vari sirumani or three months or short term Kothamalli samba, or ADT 20 *Co.* 19 *or Chingleput Sirumani, Garudan scmba, Sadai samba Chinna samba Nellore samba* (*ADT*) 11) *fine Tanjore Konakuruvai.*		
	XII. *Bellary.*		
GEB 24 variety. Bangaru Khadi Bangaru Theegalu.	Sanna vadlu and Sepoy vadlu	Mundla vadlu or Karusambalu.	....
	XIII. *Visakhapatnam.*		
Kichili samba, Kasi Pichodi, Vankasannam, Delhi Bhogam, Bangaru Theega.	Maharajabogam, Sunkisannam, Ratna Choodi Navakoti sannam, Timidisannam, Jayapore sannam Gunupur sannam, Sanna Akkulu, Krishnakatukulu, Swar-adhara, Bayahunda, Balarambhogam, Guthi Kichili.	Mypalli, Akkulu, Punasa Akkulu, Konamani, Ramasagaram, Ramagada, Akusari Peddavari, Bobbiliganti and Garikisannavari.	....

	XIV. *Anantapur.*		
Delhi Bhogalu, Bangaru theegalu ..	Maharaja Bhogalu, Tella sanna vadlu, Yerra sanna vadlu.	....	Kesari , Chennangi and Budama.
	XV. *Nilgiris.*		
Gandasale	Valan samba	Cheruvalli, Cherunellu, Kothandan, and Chintamani.	Marnelli.
	XVI. *Salem.*		
Kichili samba or Chinna Kitchidi, Sugadas, Jeeraga samba, Konakuruvai Peria kitchidi, Kasi Pichodi, Thayyamaili and Thanga samba.	Vellai samba, Sadai Samba, Poombalai or Karthigai samba Perinthandu samba, Chinna samba, Garudan samba, Kelaron samba, Peria samba, Theyya samba Banku paddy.	Kallundayan or Kallimathan Gundan samba or Attul Samba, Vellimadayan, Rangoon samba, Poonkar, Sadai kar, Vellakar, Pudupatti samba and Veppaka samba.	Mattaikar Sarapalli, Arpatham kuruvai, Kottaikar, Arputhamkodai, Manavari, Rose kar, Pedda Byravadlu, Pillan samba Neermulugi paddy and Savullu samba.
	XVII. *South Kanara.*		
Jeerasale, Ghandasale, Sannakki, GEB 24.	Maseathi Boiled and Raja Kayama.	Raw rice from varieties other than those in I sort. Cuddu (Boiled) Kolke (Boiled) Chintamani Chennullu and Elumbala.	Marnellu, Suggi and Rashi which include Thelasalukayama and Tavvan, Channel Kanva hulluga, Kuchige, Kaje and Kumari.
	XVIII. *Kurnool.*		
Kichidi, Molagulukulu, Bangarutheegalu and *Delhi Bhogalu.*	Maharajabhogalu, Ethagullalu, Vendipulu, Sambhavulu, Circar paddy Nandyala sannalu.	Vankelutella	Vankelu-Yerra, Budamalu and Erra Bokkalu.
	XIX. *Tirunelveli.*		
GEB 24 or Kichili samba and Toppai samba.	*Anaikomban*, *Chingleput sirumani*, *Milagi*, Coimbatore samba, Yeerkusamba, Suraikandi, Seemai sandi Sendivinayagam, Poombalai, Karthigai samba, Arikiravi, Semibili and Vasarakondan.	Kolavalli Mappillai samba, Avasara samba and Puzhuthipiratti.	Karasamba-white, Karasamba-red Thuyyamalli, Manalvari, Kalmanavari Sengunni, Maikuruvai and Kuruvaikalyan.

STATEMENT V.—*Statement showing the classification of various paddy varieties for Civil Supplies procurement in Madras by each district*—cont.

(Civil Supplies Department Classification)—*cont.*

Special sort. (1)	*Fist sort.* (2)	*Second sort.* (3)	*Third sort.* (4)
		XX. *Coimbatore.*	
GEB 24 or Sinna Kichidi or Thoppai samba, Co 1 Peria Kichidi.	Ayan samba (Co 11), Chingleput Sirumani (Co 19), Garudan samba or Sirumani or Nellore S. Samba (ADT 11), Gobi Sadai samba (Co 7), Tinnevelly Anaikomban (Co 8), *Jadamolagolukulu* (*Co.* 15) *Poombalai or Karthigai samba Co* 2, *Co* 3 *of Ottunellu or white paddy.*	Gobi Anaikkomban Co 4 (3), T 6 2 or Rangoon Samba, ADT 5. Garudan Samba, Perumani Nattugarudan Samba.	*Cobikar Co* 10, *Co* 13 *or Arputhan kodai, Company kuruvai, ADT* 3 *or ADT* 4 *Mattakkuruvai.*
		XXI. *Malabar.*	
GEB 24 or Kichili, *Jeerasale or Jeeraga Samba.*	Rajakayama, Anaikomban of Palghat, Kavinginpoothala (early and late).	Aryan, Ponnaryan, Eravapandy (early and late) Veluthurai Kayama, Tavalakannan, Mundakakutly, Kayama, Tekkan, Vellakoli, Annachamba or Vella chamba, Valiachampan, Kurumakyama, Arikirai.	All other varieties not included under special I and II sorts.
		XXII. *Ramanathapuram.*	
GEB 24 or Kichili, Co 1 or *Peria Kichili,* Jeeraga samba.	*Co* 16 *or Bentha Molagulukulu* Varigarudan Co 2 or Karthigai samba, Thillainayagam, Kurangu samba, Nellore samba, Chinna samba, Muthavellai, Garudan samba, *Senthinayaka* (*Co* 12), Pulithi samba, Sirumaniyan, Vathialagundu samba, Co 8, Araikomban, Milagi, Vellaikattai or Muthu vellai, Chittadiyan.	Poongar, *Manavari-white*, Tanjore Kuruvai (ADT 3 and ADT 4), Sandikar, Ampathankodai, *Swarnavari* Vadakathikar Mixture of white varieties *Arai samba.*	Chittrai-kar, Aryan, Kuruvaikalayan, Kuruvai, Tirupattur, Karum kuruvai, Kalamanavari, Muthu vellai Mudukalathur Karuthakar, Manavari-red, Kulavalai, Pulithivasate; Irangal. Kuliyadichan, Uvarirudan, Nariyan, Villupur velli, Undikar, Mixtures of Red varieties.

xxiii. *Madurai.*

Doppi (GEB 24), Bayyakonda or Vaikunda samba.	**Poombalai (Co 2), Nellore samba (ADT 11), Sithayankottai, Samba, Maikayankottai samba, Karthigai samba, *Coimbatore samba*, (Co 15) *Jadamolagolukulu* (Co 16) *Bontha Molagolukuku* (Co 19) *Chingleput Sirumai*.**	**Thangamani, Arai samba, Puluthi samba, Vellian samba, Miligai samba, Virali samba, Company vellai, Kottai, Podimilagi, Sadaimilagai, Nellore samba (ADT 5), coarse.**	**Sirkar Arupathankodai, Local Ampathankodai, Vellaikar, Perunel, Kuruvai, Red kar, Sirumani, Kolaivalai, Sornavalli, Thillai, Kar paddy, Semipillipaddy, Vellai kodai, Velan and Karmaguruvai.**

xxiv. *Madras.*

	Chinna samba.	Vaga samba.	
	Gundu samba.	Samba.	
	Sirumani.	Kar (red).	

xxv. *Cuddapah.*

GEB 24 or Kichili, Sukhadas, *Coimbatore Pishanam*, *Co* 11 *or Peria kichili*, Chittimutyalu, Murazalli, Molagolukulu, Basumati.	Chandravanke, Co 2 or *Poombalai*, *Nellore Pishanam*, *Pidikadu Pishnam*, *Pariga Pishnam*, *Pitchaipishanam*, *Vallur Pishanam*, *Tellasannavadlu*, *Thimmapuram Vadlu*, *Yerrasanna vadlu*, Pattidu Sambavalu.	Thokavadlu	Budda vadlu, *Chennangi*, *Vanka*, *Nallavadlu*, *Budara and Manikatlu*.

Note.—Contractions against names and numbers of strains used are as follows :—

Adt.	denotes	Aduthurai.
Co.	denotes	Coimbatore.
Mtu.	denotes	Maruteru.
Ptb.	denotes	Pattambi.
T.	denotes	Types.

STATEMENT VI.—*Quantity and value of produce graded under 'Agmark' in Madras* (1938–39 *to* 1949–50).

	Quantity.	*Value (lakhs of rupees).*
Eggs (lakhs)	**194·3**	**15·61**
Oranges (lakhs)	**82·3**	**9·57**
Cigarette tobacco (million lb.) ..	**205·73**	**2,732·60**
Rice (000 maunds)	**896·7**	**62·00**
Lime fruits (lakhs)	**20·8**	**0·20**
Potatoes (000 maunds)	**78·6**	**3·22**
Gingelly oil (000 maunds)	**1·3**	**0·56**
Cotton (000 bales)	**1·2**	**1·30**
Jaggery (000 maunds)	**2 4·6**	**0·77**
Fruit products (000 gallons)	**5·2**	**0·30**
Ghee (000 maunds)	**7·3**	**12·43**
Mangoes (000 maunds)	**26·9**	**1·04**
Total ..	–	**2,925·70**

CHAPTER 30.

AGRICULTURAL EDUCATION AND TRAINING.

Early history—The Saidapet College Diploma Course—New College at Coimbatore—Affiliation to the Madras University and the institution of a degree—Syllabus and other details--Short courses in Agriculture—second Agricultural College at Bapatla affiliated to Andhra University—M.Sc. Degree in Agriculture, provision for—The nature of education in the two Colleges—Elementary agricultural education—Agricultural middle schools, Anakapalli, Taliparamba and Usilampatti, their failure—Rural education, juvenile schools attached to farms and Agricultural Research Stations—Training courses—Short courses in practical agriculture and practical training to sons of land-owners in agricultural research stations—Short courses in co-operation, soil conservation, malt making, fruit canning, horticultural practices—Diploma for advance horticultural course—Agricultural training for Koya boys—Scheme for training fieldmen and maistris—Agricultural education for farmers in Ceded Districts—Training of rural blacksmiths at the Research Engineer's workshop—The Agricultural Training School, Orathanad—Appendices showing prizes, medals and scholarships available at the Agricultural colleges, Coimbatore and Bapatla.

Introduction.—The object of the Agricultural College in the State as elsewhere in India has been two fold: (i) To train the personnel required to staff the Agricultural Department, and (ii) to create a class of educated farmers, who will act as pioneers in adopting progressive methods in agriculture, and lead the way for other ryots. While the latter object has not been fulfilled to the extent visualized by the early sponsors of Agricultural Education, the colleges have performed the function of training men for the agricultural departments, a function, as recognized by the Royal Commission on Agriculture in India, of the utmost importance for the welfare of the State.

Collegiate Education—Early history of Agricultural Education.—Madras is the pioneer among the States in India in the matter of imparting instruction in Agriculture. A few apprentices derived the benefit of instruction of an elementary character given at an Experimental Farm at Saidapet from 1868 under the charge of Mr. W. R. Robertson, M.R.A.C.

Eight years later, in 1876, the imparting of instruction in agriculture was organized on a more systematic basis with the founding of a school of agriculture at Saidapet itself with an Experimental Farm attached to it. Mr. Robertson was appointed Principal of the school. The educational side of his work was controlled by the Director of Public Instruction while the management of the farm was controlled by the Board of Revenue. Two years later the name of the school was changed into that of Agricultural College.

In 1886, the Madras Technical Education Scheme came into operation, by which technical examinations were conducted in various subjects, among which Agriculture was included. Two courses of studies, one of three years leading up to the Diploma in Agriculture and the other of one year leading to the Group Certificate in Agriculture were introduced.

This scheme was found to be defective in several respects, chief among which was the excessive number of subjects and their range. The closing of the experimental farm added to the difficulties, by restricting the scope for practical work. As a result of the recommendation of a Committee which examined the courses of study in 1888–89, the Government in 1890, directed the abolition of the junior course and gave the Director of Agriculture, who was then a member of the Board of Revenue, a voice in the management of the College. Difficulties attending the practical course consequent on the closing of the farm were removed by making available enough land to serve the purpose.

The Diploma Course continued with such minor alterations as were found to be necessary from time to time till a complete reorganization was carried out on the recommendation of Mr. J. Mollison, the Inspector-General of Agriculture, who visited the College in 1902–03. As per Mr. Mollison's findings about its unsuitability for the growing needs, the College at Saidapet was closed in December, 1907, with the passing out of the last batch of students that entered its portals in January 1905. With this the history of the Saidapet College closed.

New College at Coimbatore—The College.—Concurrently with the decision to terminate the College at Saidapet, steps were taken to found a college in the mofussil which contained all the representative soils of South India and where different systems of cultivation could be practised. A site near Coimbatore Town was selected and construction of the College building was started in 1906 and was completed, and occupied in 1909. The first batch of students admitted in 1908, received instruction in unoccupied bungalows, till the completion of the College buildings.

The course so far in operation was found to be unsuitable and a change involving termination of studies of applied sciences with an examination at the end of the second year and devotion of the entire third year to the study of the practice and business of farming, followed by tours to selected tracts, was introduced.

A change again was found to be necessary as the syllabus was too elaborate for such of the students as desired agricultural education for its own sake. In 1913, to meet the needs of such unequally equipped students, two courses, a certificate course, mainly practical, of two years' duration and an advanced one—Licentiate Course—of a further 20 months for the pick of the students as judged by the rank secured in the Certificate Course examination, were started. The last batch of students of these courses passed out in 1925.

The Agricultural College, Coimbatore, was affiliated to the Madras University in 1920 with a three-year course leading to the Degree of B.Sc. in Agriculture of the University of Madras. The minimum qualification for admission to the degree course was raised to a pass in the Intermediate Examination in groups I and II.

The first batch of students that qualified for the Degree by passing the examinations held at the end of the three-year course had the Degree conferred on them at the Convocation held in 1923. The teaching of different subjects in the College was done mostly by the heads of research sections in addition to the research work. Towards the end of the year 1926, the Government created the post of a whole-time Principal and an exclusive teaching staff with complete control of teaching in all subjects of instruction.

This system continued till the middle of 1938 when reversion was made to the old system under which some of the heads of research sections were again asked to assume responsibility for teaching.

Up to the year 1932, tuition and lodging were provided free to all the students coming from Madras State and Coorg. In addition to this, during the earlier years of the institution of the Degree Course, stipends were given to all the candidates selected for admission with a view to attract the right type of men. But in the course of next few years, these inducements were found unnecessary, agricultural education becoming increasingly popular, and the number of candidates seeking admission far exceeded the number of available seats. The stipends were abolished, substituting in their place, a few scholarships for the benefit of the Backward Classes. From the year 1932–33 onwards, fees were levied both for tuition (Rs. 120 a year) and lodging (Rs. 24 a year). Students coming from other States had to pay as before fees at an enhanced rate of Rs. 1,200 per year, this sum being computed to be equivalent to the cost incurred by the State in providing agricultural education per student in the college. The levy of capitation fees to outsiders was stopped in 1950, consequent on the birth of New Constitution.

Number admitted and changes in the syllabus.—Twenty students were admitted annually previous to 1926 for the Degree Course. The number of admissions was subsequently raised to 48 on the completion of the Freeman Building which provided space for housing the College. From 1944 to 1948 the strength was raised to 96 with three seats reserved for lady students. This increase was made with a view to provide adequate trained personnel for the execution of several Post-War Reconstruction Schemes relating to development of Agriculture. In 1949 the number was, however, reduced to 80.

In 1945 a second Agricultural College was opened at Bapatla in the Guntur district.

Previous to 1932 there were only two examinations at the end of the second and final years. From 1932, however, three examinations are being held, one at the end of each year.

The original syllabus was enlarged in 1943 instituting Agricultural Economics as a separate subject. This was further enlarged in 1948–49 by the addition of another subject, viz., 'Propaganda'.

Students' Hostel.—A hostel is provided for the students. At present there are 134 double rooms and six single rooms. Separate messes are run for vegetarians and non-vegetarians. In 1947, under orders of the Government, the management of the messes was transferred to the students. Each mess is managed by a committee of three students elected by the members of the mess. The general management of the Hostel is vested in the Principal who is the ex-officio Warden. He is helped in his work by a Senior Deputy Warden and Junior Warden.

Games.—Sports form an important item of extra curricular activity and there are a number of Cups and Shields donated for creating healthy competitive spirit among the students. Extensive playgrounds are provided near the College Hostel, where cricket, hockey and football are played. In 1946, an additional hockey field was laid out to meet the requirements of the increased number of students participating in games. In addition to the above-mentioned games, tennis, tennekoit, volley ball, basket ball and badminton are also played. There is also provision for indoor games, such as table tennis, carrom, chess, draughts, etc. Staff members are appointed as coaches for cricket, hockey, football and tennis. A member of the staff who is the Vice-President of the Students' Club guides the Secretary and Games Captains in their activities.

Library.—There is a well equipped library attached to the College and Research Institute, the number of books and periodicals in 1949–50 being 47,565.

Museum.—The College Museum is housed in a spacious hall in the Freeman Buildings. The collection is representative of different tracts of South India and is of considerable educative value.

M.Sc. Degree.—Facilities are available in the College and Institute for graduates in Agriculture and other science subjects for pursuing research work with a view to qualifying for the M.Sc. Decree of the Madras University.

Short courses in Agriculture.—With a view to meet the needs of young men belonging to families owning lands and who cannot afford to undergo the University courses in Agriculture and who, at the same time, require a sufficient knowledge of scientific and improved methods of agriculture and allied subjects, the Government were pleased to sanction in February 1933 the institution of short courses in practical agriculture, not exceeding one year, at the Agricultural College, Coimbatore.

The details of the different courses in which instruction was imparted are given below :—

	Name of course.	*Period covered.*	*From*	*To*
	(1)	(2)	(3)	(4)
1	Farm management ..	Nine months ..	June.	March.
2	Dairying	Three „ ..	April.	June.
3	Care of animals	Three „ ..	April.	June.
4	Insect pests and diseases ..	One and a half months.	October.	December.
5	Malt making	Half month ..	April or	May or September.
6	Manures	One and a half months.	October.	November.
7	Crop improvement ..	Three fourth months. ..	December.	(1st to 22nd February).
8	Jaggery making	Four weeks. ..	..	..
9	Vegetable gardening including Horticulture, or	Six months ..	August.	January.
	Horticulture alone ..	Three months ..	October.	December.
10	Bee-keeping	One month ..	February.	

Each course is complete in itself but two or more courses may be combined. Young men of about S.S.L.C. standard or its equivalent and with minimum age of 16 years were made eligible to join the courses.

The courses were popular but are now kept in abeyance due to the increased admissions to the Degree Course.

Second Agricultural College, Bapatla.—The Bapatla Agricultural College was opened in July 1945, under the Post-War Reconstruction Scheme, for providing an adequate number of trained personnel for the execution of the various Post-War Reconstruction Schemes. Several sites were inspected and Bapatla in Guntur district was finally selected as a suitable place. Bapatla is central for Northern Circars and the Rayalseema and serves mostly the needs of Andhra Desa. The College is housed in the old District Board High School Buildings to which an additional wing has been added to accommodate lecture halls and laboratories. Fairly extensive areas of lands are available for providing playgrounds and raising garden crops.

All the students, unless exempted for special reasons, are required to stay in the hostel attached to the College. The main hostel accommodates about 115 students. The rest of the students are at present housed in seven buildings rented temporarily. A second hostel building is under construction.

A farm comprising an area of 59 acres was taken on lease temporarily at Machavaram about 10½ miles to the north of Bapatla. The distance of the farm being 10½ miles from the College, six Government buses have been provided for taking the students regularly to and from the farm. This farm was relinquished on 30th June 1950. A farm comprising an area of about 340 acres which will admit of all the three types of cultivation,

viz., wet, garden and dry, has been acquired. Henceforth, this will be the permanent farm of the College. The new farm is situated about 2½ miles to the north of the College and is on the Bapatla-Guntur Road.

The course of study in the College extends over three years, leading to the B.Sc. (Ag.) Degree of the Andhra University, 96 students being admitted each year with three seats reserved for lady students. Since 1949–50 the number of admissions is limited to 80. Candidates for admission to the course should have passed the Intermediate Examination having offered as optionals Chemistry and any two of the following subjects: Mathematics, Physics, Biology, Botany, Natural Science, Zoology and Agriculture.

Three examinations are conducted for the Degree Course, one at the end of each year of study. The candidates should pass in all the three examinations before qualifying for the degree.

M.Sc. Degree in Agriculture.—Recently the Andhra University, on the recommendations of the Board of Studies in Agriculture, has framed the necessary regulations, for candidates to take up, under the guidance of a recognized professor, a course of study in some research problem connected with Agriculture and qualify themselves for the M.Sc. Degree in Agriculture, by a thesis and by a written examination at the end of the course.

What is taught in the Agricultural College, Coimbatore and Bapatla.—The Agricultural education that is being given in Coimbatore and Bapatla may be said to be almost an ideal of what sound teaching should be; where theory and practice go not only hand in hand, but where both keep pace with the latest developments. The course leading to the B.Sc. Degree in Agriculture is one of three years, and consists of a fairly advanced study in agriculture and its allied sciences, and has been considered as one of the best in India. The instruction in farming has many features of its own. The students participate in all farm operations. They handle animals, fit up ploughs and work them in dry lands as well as in the puddles of the wet lands. They dig and cart manure, form plots, work the mhotes, irrigate the fields, raise seedlings and transplant them, harvest the crops, cart and thresh the produce, and in fact take part in every farm operation. They are also taken on tour to typical agricultural tracts of the State. This comprehensive training in practical agriculture is by far the most important part of the curriculam for it gives the students an insight into their future work and enables them to learn the art and science of improved agriculture as a profession, first hand.

Another branch of agriculture taught is dairying. This includes the care of dairy cows and calves and the proper method of varying the feeds according to milk yields. The calves are weaned immediately after birth and handfed with regulated quantities of milk. This 'weaning' has two advantages. The feeding is regulated and diseases caused by over and under feeding are prevented. The calves thus weaned grow into healthy animals.

The cows get accustomed to milking without calves. The data of milk yields thus obtained are reliable. The students attend to milking of the cows and participate in the recording of milk yields. They are also given practical training in the disposal of milk on hygienic lines. The milk is separated into the more valuable cream and the less valuable skim-milk containing little or no fat. The students learn first-hand advanced methods in dairying and butter making. The practical training in animal husbandry equips them to take good care of the farm animals and to treat them for common ailments.

In Botany, besides systematic and physiological aspects, a special detailed study of crop botany is made. Every crop is studied thoroughly. A fair knowledge of the inheritance of characters in crops is imparted. The practical application of this branch of science is demonstrated to students in the research and breeding stations where advanced work on plant breeding is in progress. In Agricultural Chemistry, they get a good training in the analysis of soils, manures, fodders, oil-cakes and milk. The course in Entomology and Mycology is of practical value to help them to take timely remedial and preventive measures against the pests and diseases of crops. Lastly, the study of Engineering gives them a working knowledge of engineering, pertaining to farm machinery and building constructions.

The graduates of these colleges are well fitted to serve in any branch of the Agricultural Department, in the Co-operative and the Revenue departments and also to take service under Zamindars and landed aristocracy in the management of their lands besides serving as science assistants in schools and colleges. They are in a position to take up independent farming provided they own or purchase or obtain on favourable terms sufficient area of land of average fertility.

Board of Honorary Visitors to the Agricultural Colleges.—With the object of associating a certain number of non-official gentlemen in an honorary and advisory capacity with the Agricultural College and Research Institute, Coimbatore, and the Agricultural College, Bapatla, the Government appointed some selected gentlemen who take practical interest in Agriculture. The honorary visitors, whenever they visit the institution, are required to enter any remarks and observations they may wish to record regarding the work in progress in the college.

The Government in the year 1942 replaced the system of appointing visitors by the constitution of a " Board of Honorary visitors ", consisting of the Principal of the College as Secretary, the Collector of the District as the Chairman, the Deputy Registrar of Co-operative Societies of the district and three non-official gentlemen from the district in which the college is situated. The functions of the Board are purely advisory. The Board should hold half-yearly meetings at the Agricultural Colleges. The proceedings of the meetings are to be forwarded to Government.

Elementary Agricultural Education.

Agricultural middle schools.—At the instance of the Government of India, a Conference on Agricultural Education in India was held at Simla on 12th June 1917. This conference passed certain resolutions based on the policy that apart from the establishment of Agricultural Colleges in States attempts should be made to develop a method of direct tuition in Agriculture to agriculturists of school-going age.

One of the several resolutions passed was that every rural district should have one or more Agricultural Middle Schools usually situated near the demonstration or experimental farms.

For implementing this resolution, it was reported to Government early in 1918, that it would be enough to start two experimental upper primary Agricultural Schools—one for the Tamil area near the Central Farm, Coimbatore, and the other for the Telugu area near Anakapalle Farm. The Government accepted the proposal in 1918 and ordered that a Joint Committee of the Officers of the Agricultural and Education Departments should work out the details of the proposed two Agricultural Middle Schools. The two agricultural middle schools were opened in 1922—one at Anakapalle in Visakhapatnam district and the other at Taliparamba, Malabar district.

(i) *Agricultural Middle School, Anakapalli.*—The Anakapalle school did not prove a success. Despite propaganda, it was difficult to obtain students. As there was no demand for this class of education in this district, the school was closed in December 1927.

(ii) *Agricultural Middle School, Taliparamba.*.—In regard to the Agricultural Middle School, Taliparamba, the following statement gives the number of boys who sought admission to the Agricultural Middle School each year, since it was started, the number admitted and the number of boys who passed out of the school and how they are employed :—

Year.	*Number of boys who sought admission.*		*Number admitted.*	*Number who completed the two years' course.*
	Number who applied.	*Number who appeared for interview.*		
(1)	(2)	(3)	(4)	(5)
1922	20	20	20	First year
1923	20	16	16	Second year
1924	33	27	27	14
1925	24	17	17	13
1926	34	19	19	18
1927	79	38	38	4
1928	40	22	19	11
1929	41	20	17	30
Total ..	291	179	175	90

HOW THE BOYS ARE EMPLOYED.

Number engaged in farming.	*Number employed on plantations.*	*Number employed as teachers.*	*Number prosecuting further studies.*	*Number employed as feldmen in the Agricultural Department.*	*Number unemployed.*	*Not known.*	*Total.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
31	4	10	12	2	26	5	90

"It is evident that there is no real demand for this type of education. On the average we have been able, by dint of tremendous efforts on the part of the Deputy Director's staff, to get only half the number of students that the school can accommodate. Of these only half manage to struggle on to the end of the course and of these only one-third find their way back to the land; that is, the school is working at only one-twelfth efficiency. An average of four students per year who return to agricultural occupation is a very poor return for such a costly outfit. We could achieve as good a result if there were only a limited real demand for this type of education by running the farm in an ordinary way and taking in boys to work on the farm giving them accommodation and charging them full rates for their food, and without expensive equipment. There is no real demand for this type of education however."

On the recommendation of the retrenchment committee the school was closed on 1st April 1932.

The Agricultural Middle School at Usilampatti.—This school, in Madura district, was opened in the year 1929 and was maintained by the District Board, Madura, with the aid of a contribution from the Government. The object of establishing the school was mainly to impart Agricultural Education to boys belonging to Kallar community. Only those boys who have lands to which they can go to were to be admitted in the school and the strength was to be 40 boys. The Agricultural Department lent the services of two upper subordinates to the school, one to be Headmaster of the school and the other for farm work. Government gave a grant of Rs. 13,909 in 1928–29 and Rs. 6,160 in 1929–30. The strength of the school up to 1937–38 is given below :—

1929–30 ..	14	1932–33 ..	38	1935–36 ..	30
1930–31 ..	15	1933–34 ..	39	1936–37 ..	26
1931–32 ..	23	1934–35 ..	32		

The school was ordered to be closed at the end of the school year 1937–38, as Government declined to grant subsidy for running of the school.

Rural education—Juvenile schools attached to Agricultural Research stations.—The schools for juvenile and adult labourers at the Central Farm, Coimbatore, and the Agricultural stations at Palur and Anakapalle were started during 1927–28 and are being continued with certain modification on temporary basis.

The object of the schools is to provide general and agricultural education for the sons of labourers, who would not otherwise go to school. The schools aim at inculcating to the boys improved methods in farming practices obtaining in the neighbourhood. These schools do not aim high but play a useful part in the problem of agricultural education in the country and are worth the money spent on them.

The school at Coimbatore was reorganized in 1932, and as a consequence, the strength of the school increased. The night schools at Coimbatore and Palur were closed in 1935 and 1936 respectively under orders of Government.

The sons of farm labourers and a few others are paid full day's wages for half day's study at the school and half day's work at the Farm. From 1942 the schools at Palur, Anakapalle and Coimbatore are complete elementary schools with five standards. The schools are on temporary footing and sanction for their continuance in being renewed every year.

Elementary School attached to Agricultural Research Station, Samalkota.—The Government sanctioned the opening of a school at the Agricultural Research Station, Samalkota, during 1942 to provide elementary education for the juvenile and adult labourers employed at the Station at a cost not exceeding Rs. 660 per annum.

Government sanctioned the creation of the post of a Lower Elementary trained teacher in the scale of Rs. 20—2/2—24—1/2—28 for the Elementary School for juveniles and adult labourers at the Agricultural Research Station, Samalkota.

The school was started with three standards and admission was limited to 15 boys for the day school and 20 for the night school. The Deputy Director of Agriculture was permitted to admit at his discretion boys in excess of the number prescribed for the day school but the boys so admitted were to receive free tuition but were not entitled to wages.

The boys may attend school either in the morning or afternoon and will work on the farm for the rest of the day. Instruction is free and they are paid wages at boys' rates for each day's attendance at school.

TRAINING COURSES.

Short course in practical Agriculture at Coimbatore.—Short courses on the following subjects were given at the Agricultural College, Coimbatore, and the number of candidates who underwent the course during the period 1937–38 to 1941–42 are furnished :—

	1937–38.	1938–39.	1939–40.	1940–41.	1941–42.
1 Farm management	14	9	10	12	9
2 Horticulture and vegetable gardening	2	2	3	2	..

	1937–38.	1938–29.	1939–40.	1940–41.	1941–42.
3 Insect pests and diseases	3	3	2	3	..
4 Dairying	4	..	1	2	..
5 Malt making	4	..	1	6	..
6 Care of animals	2	4	3	5	..
7 Bee-keeping	2	5	3	5	..
8 Jaggery making	2	4	4	5	..
9 Farm implements, manuring and crop improvement	2	4	4	4	..

The students who underwent the Farm Manager's course attended other short courses also mentioned above. The courses were kept in abeyance due to lack of accommodation consequent on the increased admissions to the degree course.

Short courses in practical agriculture at Nandyal and Taliparamba.—In September 1935, a proposal was made to Government for starting short-course training in Agriculture at the Agricultural Research Stations, Nandyal, Taliparamba and Kalahasti. But the Government ordered the opening of short courses in practical agriculture at Agricultural Research Stations, Nandyal and Taliparamba, only during 1936–37.

Nandyal.—The course extended over a period of nine months from July 1937 to March 1938. Nineteen applications were received for admission, but only six candidates appeared for interview. All the six were selected, but only three completed the course. The students underwent training both in theory and practice, two hours a day having been allotted for the former and six hours for the latter.

Taliparamba.—The course was given for about eight months commencing from August 1937. Five candidates were selected for admission of whom four joined the course and one left soon after joining. The remaining three completed the course satisfactorily and were reported to have gone back to the land after training.

Practical Training in Agriculture to sons of landowners.—With a view to give training in practical agriculture to unemployed educated young men in land owning agricultural families and thereby affording them an opportunity to take an intelligent interest in their own lands, the Government ordered in 1936 that arrangements be made to train 150 students for a period of four months during the cultivation season (September to December) at the several agricultural stations in the State. The young men should have passed at least the S.S.L.C. Examination and should be drawn if suitable candidates are available from all the districts at the rate of not less than six in each. They were to be nominated by the Collector of the district in consultation with the local officers of the Agricultural Department and were to be finally selected by the Director of Agriculture. The selected candidates were to be paid a stipend of Rs. 15 each per mensem.

The number of candidates who were taken for the training at the various Agricultural Research Stations during 1936 was as follows :—

Name of Agriculural Research Station. (1)	*Number taken for training.* (2)
Anakapalle	6
Samalkot	6
Maruteru	11
Guntur	9
Hagari	6
Nandyal	7
Kodur	6
Palur and Tindivanam	14
Gudiyattam	6
Kalahasti	5
Aduthurai	8
Koilpatti	13
Coimbatore	13
Nanjanad	6
Pattambi	6
Kasaragod	6
Total	128

Course in co-operation.—In 1934 a course of instruction in Co-operation, Auditing, Book-keeping and Banking was instituted for the B.Sc. (Ag.) students to enable them to pass the Government Technical Examinations and to qualify for appointment as Inspectors in the Co-operative Department. As there was no proper response from the students for the above, the course was abandoned in 1936.

Soil conservation training at Bellary.—Soil conservation is a combination of Agricultural Engineering and Afforestation practices and as such a knowledge in all the branches is essential. The principal staff to be entrusted with the scheme was, therefore, trained at the Soil Conservation Institute at Sholapur. Among the various soil conservation practices such as Contour Bunding, Contour Trenching, Gully Plugging, Terracing, Strip Cropping, Rotation of crops, Manuring, Weed and Pest Control, etc., it is proposed to execute only the Engineering practices such as Contour Bunding, Contour Trenching, Gully plugging, Terracing, etc., by the department as these measures have to be adopted on a catchment. The biological methods of soil conservation are proposed to be advocated for adoption. As such the execution will mainly fall on the Engineering side. As requisite Engineering personnel are not available in the department, necessary training in Soil Conservation with particular reference to Soil Engineering was given to eighteen Agricultural Assistants, who are posted as Soil Conservation Assistants. Besides it was felt that the training at Sholapur was more theoretical and for immediate employment on the scheme they would require further training in practical work in Engineering, particularly surveying. Eighteen Agricultural Graduates were, therefore, trained in Soil Conservation by the Assistant Agricultural Engineer at Bellary.

Short course of training at Malt Factory, Coimbatore.—In 1944, Government sanctioned the institution of the one month's training course at the Malt Factory. A number of candidates received training in the factory from the year 1944 to the end of 1949.

Short course in Fruit Canning and Preservation.—In 1945, the Government sanctioned the institution of a short course of training in Fruit Canning and Preservation at the Fruit Research Station, Kodur. The duration of the course is for a period of three months or for a shorter period according to the choice of the individual trainee and his capacity. Only one or two students should be admitted for training at a time. The students are charged a fee of Rs. 25 each for the entire course which should be paid in full in advance. The number of persons who underwent the three months' training in Fruit Canning and Preservation is noted below :—

Year.	*Number of persons.*
1945	2
1946	6
1947	4
1948	6
1949	5
Total ..	23

Short course in Horticultural practices.—In 1944, the Government sanctioned an one-year course training in orchard practices; only two candidates were trained up to January 1950.

In 1947, the Government sanctioned one month's training course in methods of grafting at the Fruit Research Station, Kodur. Seven candidates were trained under the scheme. Besides, four Upper Subordinates and 45 regular coolies of the department were given training for varying periods.

Horticultural course.—A diploma course and a certificate course for specialized training in Horticulture were instituted in the year 1948. The diploma course is open both for private candidates and subordinates of the Agricultural department, while admission for the certificate course is restricted to fieldmen serving in the Agricultural department. Three to four scholarships of the value of Rs. 100 each are offered to the private candidates selected for admission. The subordinates of the Agricultural Department draw their usual pay and allowances during the course. The training is in charge of the Fruit Specialist, Madras, and at the end of the courses, examinations are held on the basis of which Diplomas and certificates are awarded. The syllabus for the advanced course leading to Diploma in horticulture is comprehensive, and covers the full range of subjects relating to horticultural theory and practice while the syllabus for the certificate course lays emphasis on the practical side such as grafting of fruit plants, nursery raising, vegetable gardening, etc. Both the courses have proved useful and popular.

Agricultural training of Koya boys.—In 1929, the Government sanctioned the training of six Koya boys in practical agriculture at the Agricultural Research Station, Anakapalle, for a period of nine months and an expenditure of Rs. 870 towards the payment of stipends and travelling allowance. Only candidates who had studied up to the primary standard and who could read and write Telugu were to be selected for the training. The grant of the stipend was subject to the conditions (1) that the candidate executed a bond binding himself to serve the department, if there was need, as a demonstration maistri or coolie in the Agency tract at least for a period of one year after the training is over, (2) that, if the candidate discontinued the training before the prescribed period except for reasons of health, the stipends drawn should be recovered from him, and (3) that he should put in an attendance of at least 25 days per month for the drawal of the stipend.

The training actually commenced only from June 1940, as the Agent to the Government of Madras, Cocanada, was able to select six Koya candidates only. Out of the six candidates selected, only five actually joined the course. The training imparted to the boys was of practical nature comprising practical agricultural operations of successive crops at the Agricultural Research Station, Anakapalle. All the boys gained enough practical knowledge from the training which they underwent for nine months. The same training was repeated for another batch of six Koya students in 1942–43.

Scheme of training fieldmen and demonstration maistris.—The Government sanctioned in 1945 a scheme for training 520 candidates as fieldmen and 2,740 candidates as demonstration maistris. The cost of the scheme was shared by the Government of India.

The object was to have an adequate number of non-graduate staff to meet the demand for trained personnel in the Grow More Food and Post-war Schemes of the Agricultural department.

The fieldmen candidates were trained in batches of 20 in each of the six Agricultural Research Stations, viz., Anakapalle, Samalkota, Nandyal, Aduthurai, Koilpatti and Pattambi; the course of training was for four months. The maistri candidates were trained likewise in all the Agricultural Stations at 20 in each station in batches.

The stipend paid for fieldman candidates was Rs. 20 per mensem and that for demonstration maistris was Rs. 15 per mensem. This training scheme was worked during the years 1945 to 1947 and given up at the end of 1947 after a sufficient number of personnel were trained. They were ultimately absorbed in service in this department.

Agricultural education of farmers in Ceded Districts.—In 1948, the Government sanctioned a scheme for the Agricultural education of farmers in Ceded Districts. During the 1948–49, 20 ryots from each of the four taluks of Hospet, Siruguppa, Alur and Adoni, in

the Bellary district were to be taken to the Agricultural Research Stations at Siruguppa and Bhagavathi in the same district, with the object of showing to them the improvements in irrigation farming in these areas. The Government sanctioned Rs. 1,000 towards the cost of the scheme.

Training in Food Yeast manufacture.—In 1948, the Government sanctioned the training of private candidates in the manufacture of food yeast at the Agricultural Research Institute, Coimbatore, for a period of three weeks on a tuition fee of Rs. 25 per candidate payable in advance. This training should be given by the Government Mycologist without prejudice to his normal duties.

Training in Dairy Husbandry.—Based on the recommendations of Dr. H. D. Key, Director, National Institute of Research in Dairying, a scheme for training to selected cultivators in dairy husbandry, has been put in force in Coimbatore. The first batch of 12 selected cultivators had their training in 1950 and the scheme has been sanctioned for 1951 also.

Scheme for the training of rural blacksmiths at the Research Engineer's workshop.—This scheme of training began with small venture conducted with a senior rural blacksmith deputed from Hosur and a second man from Pollachi in November 1940 and January 1941 respectively. Enquiries were then made of the several District Agricultural Officers of the chances of obtaining more rural blacksmiths for programming a regular course of training.

When this was ascertained, fifteen rural blacksmiths were reported as having expressed their willingness to undergo training in the workshops in the manufacture of spares for improved ploughs of the various types recommended and demonstrated by the department. On the basis of this number, a scheme of training was drafted with details of expenditure and proposals were submitted to Government who approved of the scheme in 1942. When the sanctioned scheme was proposed to be commenced from the beginning of January 1942, only one smith from Pollachi reported himself and completed his two months' training. The scheme for training of rural blacksmiths was deferred for the duration of the war. However, to such of the rural blacksmiths as turn up for the training, training is given.

The Agricultural Training School, Orthanad, Tanjore district.—The school was sponsored by the District Board, Tanjore, and financed by the Raja's Endowments (Chatram) Funds. This scheme was sanctioned by Government in 1947. Government also agreed that during a year in which the expenditure on running the school exceeds the income, the net expenditure be borne equally by the State Government and the Tanjore District Board and that if in any year the income exceeds the expenditure, the nett income be credited to the institution for being spent on its expansion and development. The school is now no more a Government Institution

and is being managed by the District Board, Tanjore. This institution was started with a view to impart practical training in scientific agriculture to the sons of landholders and of prominent cultivating tenants who pledge themselves to go back and develop their lands after completing the course. Such a pledge was taken to ensure that the boys who got the training did not aspire for any job in the Agricultural department such as maistris or fieldmen.

Out of 45 candidates selected by the advisory committee as suitable for admission in 1948–49, only 14 candidates joined the school; out of them two boys dropped out. The remaining 12 boys took keen interest in the training and all of them passed the final examination conducted by the Board of Examiners. In 1949–50 in spite of wide publicity only 16 boys underwent the training; of these ten were deputed by the Government from the Senior Certified School, Chingleput. This school has got a hostel to accommodate 36 boys and it has also got a farm and a dairy.

In this State about half a dozen Arts Colleges have Agriculture under Part III of the Intermediate in Science examination of both the Andhra and the Madras Universities. The alumni of the Coimbatore Agricultural College are now handling the lectures.

For the past ten years in more than a dozen high schools Agriculture is an optional subject under group C for the Secondary School-Leaving Certificate Examinations. Thus agricultural education in Madras exists in four phases, elementary, secondary, collegiate and post-graduate.

APPENDIX I.

Note on the several prizes, medals or scholarships awarded at the Agricultural College, Coimbatore and Bapatla.

Serial number and name of the scholarship, prize or medal. (1)	*When it was instituted.* (2)	*Names of donors.* (3)	*Amount.* (4)	*Detailed rules for the award of the prizes, scholarship or medal.* (5)
		Agricultural College, Coimbatore.	RS.	
1 The Robertson prize.	1910	Admirers of Mr. Robertson.	3,350	The prize shall be awarded in the form of a gold medal annually to a student of the Coimbatore, Agricultural College who obtained the highest number of marks in the subject of Agriculture in the final examination for the B.Sc. (Ag.) degree and qualified himself at first appearance in the second and final year examinations.
2 The Clogstoun prize.	1910	Admirers	1,450	The prize shall be for general proficiency and awarded to a student who obtains the highest number of marks in all College terminal examinations provided he passes all the B.Sc. (Ag.) degree examinations at first appearance.
3 The Kees prize ..	1911	Subscribers to Kees memorial fund.	750	The medal shall be awarded to a candidate who obtains the highest number of marks in Agricultural Chemistry of the final examination provided he takes his degree without failing in any of the examinations.
4 Diwan Bahadur R. Raghunadharao prize.	....	Rao Sahib A. Sethurama Ayyar.	850	The medal shall be for practical agriculture, judged as a whole on the highest number of marks obtained in all the College terminal examinations and in the final examination.
5 The D'Silva Memorial prize.	....	Madras Agricultural Students Union.	700	The medal shall be awarded for the candidate getting highest number of marks in Animal Hygiene of the second year B.Sc. (Ag.) examination.
6 The Goschen prize.	....	Rao Bahadur K. S. Venkatarama Ayyar.	500	The medal should be awarded to the student who obtains the highest number of marks in Agricultural Zoology of second year B.Sc. (Ag.) Examination.
7 The Anstead prize.	....	Do.	500	The medal shall be awarded annually to the student who stands first in class II in plot cultivation.

Serial number and name of the scholarship, prize or medal. (1)	When it was instituted. (2)	Names of donors. (3)	Amount. (4)	Detailed rules for the award of the prizes, scholarship or medal. (5)
		Agricultural College, Coimbatore—cont.		
			RS.	
8 The Rao Bahadur K. S. Venkatarama Ayyar prize.	....	Rao Bahadur K. S. Venkatarama Ayyar.	500	The gold medal shall be awarded to the best student in the first year class.
9 The Sampson Agricultural Botany prize.	....	Admirers of Mr. H. C. Sampson.	1,200	The gold medal shall be awarded each year to a student of the college who obtains the highest number of marks in Botany in the final examination for the B.Sc. (Ag.) and qualifies himself for the degree at first appearance in all the three examinations.
10 M. K. Nambiyar prize.	....	Subscribers to M. K. Nambiyar memorial fund.	425	The prize shall be in the form of books awarded annually to the student who obtains the highest number of marks at the Second B.Sc. (Ag.) examination at the first appearance.
11 Dr. S. Rangachari Technical scholarship.	....	....	7,000	The scholarship shall be awarded to a poor and deserving Srivaishnava brahmin student in the first year class.
12 Dewan Bahadur L. D. Swamikannu memorial prize.	....	....	..	This gold medal shall be awarded annually to the student who takes B.Sc. (Ag.) securing the highest number of marks in the aggregate in all the three examinations taken together.
13 The Gupta memorial prize.	....	Admirers of Gupta ..	600	The prize shall be awarded to the student who secures the highest number of marks in Agricultural Engineering in the Second B.Sc. (Ag.) Degree examination at the first appearance.
		Agricultural College, Bapatla.		
14 Dr. B. V. Nath's medal.	....	Honorary Lt. P. V. Krishnayya Choudary.	..	The prize shall be awarded annually to the student of Agricultural College, Bapatla, who stands first in the B.Sc. (Ag.) final examination.
15 Sri B. V. L. Narayana Rao's medal.	....	....	..	The medal shall be awarded to the student who obtains the highest number of marks in Agriculture at the Final examination for the B.Sc. (Ag.) Degree.
16 The Krishna Guntur Groundnut Oil Mill Associations Technical Scholarships.	....	Krishna Guntur Groundnut oil millers.	5,000	The scholarship shall be awarded to a poor and deserving student in the first year class of the B.Sc. (Ag.) course.

College scholarships, 1951–52—Agricultural College, Coimbatore.

Class. (1)	*Number of Scholarships available.* (2)	*Amount of scholarships.* (3)	*Remarks.* (4)
		State Scholarships.	
		RS. PER MENSEM.	
For Muslim Student	One	30	....
For backward Students	Five	30	....
For students who got merit II and III years only.	Two	30	....
		Scholarships awarded per annum by Harijan Welfare Department.	
II year	Six	2,250	Sanctioned in Order No. A. 4-34458/51, dated 17th April 1951, of the Director of Harijan Welfare, Madras.
III year	One	375	Sanctioned in Order No. A. 4-34458/51, dated 4th October 1951, of the Director of Harijan Welfare, Madras.
II year	One	375	Do.
III year	One	120	Sanctioned in A. 4-365395/51, dated 4th October 1951, of the Director of Harijan Welfare, Madras.
		Endowment Scholarships.	
II year, Lord Pentlands' Scholarship.	One for three years from 1950–51.	105	Sanctioned in D.A.S.D. Dis. X. No. 1426/50, dated 28th November 1950.
II year, Dr. S. Rangachari's Scholarship.	One for three years from 1950–51.	150	Sanctioned in Director of Agriculture's D. Dis. X. No. 1239/50, dated 24th October 1951.
		Scholarships awarded by the Commissioner of Coorg.	
II year	One for ten months from 16th June 1951.	25	Sanctioned in D. Dis. B. No. 3-336/51, dated 23rd October 1951, of the Chief Commissioner, Coorg, Mercara.
II year	Do.	25	Do.
		Scholarships awarded by the Central Government under Scheduled Castes and Tribes.	
III year	One	520	Sanctioned in Sc. M. No. 93/50 Sc., dated 20th July 1951, of the Secretary.
III year	One	399	Sanctioned in No. B.C./C.A.(C)-1/51–52, dated 12th January 1952, of the Secretary, Scheduled Castes, Tribes and other Backward Classes, Scholarships Board, Ministry of Education, New Delhi.

Agricultural College, Bapatla—Backward Communities.

Class.	*Number of Scholarships available.*	*Amount of scholarships.*	*Remarks.*
(1)	(2)	(3)	(4)
		RS.	
		PER MENSEM.	
I year	Five	30	....
II year	Five	30	....
III year	Five	30	....
		Merit Scholarships.	
II year	Two	30	....
III year	Two	30	....
		Muslim Scholarships.	
I year	One	30	....
II year	One	30	....
III year	One	30	....
		Director of Harijan Welfare Department.	
		EACH FOR YEAR.	
I year	Orders are awaited.	....	....
II year	Eight	375	....
II year	Two	450	Belonging to Harijan and Christian Community.
III year	Five	375	....
		Government of India's Scholarships.	
		PER HALF YEAR.	
III year	One	244	For second instalment no amount has so far been received.
II year	One	222	Do.

CHAPTER 31

EXTENSION WORK.

Translation of results of research in the ryot's fields—General policy, simple improvements and direct demonstration—The administrative set-up—Methods of propaganda and publicity—Agricultural Demonstrators and their duties—Trial plots—Observation plots—Demonstration plots—Demonstration Farms on ryots lands—Agricultural Associations, exhibitions and shows—Motor exhibition vans—Co-operative societies—Prizes and awards for improvement—Publicity—The villagers' calendar—Leaflets—Agricultural digest and press jottings—Scientific publications—Grow More Food journals in Tamil, Telugu, Kannada and Malayalam—Radio talks—Seed farms—Seed distribution schemes—Free distribution of seed—Propaganda on farmyard manure preservation, green manures, compost making—Purchase and distribution of manures—and schemes for popularising phosphatic manures—Controlled distribution of iron for agricultural purposes—Special extension courses—Takkavi loans—Land development work, the Wynnad colonisation scheme, Subsidiary food crops—Plant protection organisation.

Introduction.—The primary purpose of agricultural research work is the acquisition of exact knowledge and the ultimate purpose is the translation of this information into concrete improvements which the cultivators can adopt as part of the ordinary farming practice. This dual aspect of research work in the laboratory and demonstration and propaganda in the field may be said to form the main functions of the Agricultural department. The chief centres of research are the Research Institute at Coimbatore equipped with a staff of specialists and the Research Stations spread all over the State. In the districts the Deputy Directors of Agriculture and the District Agricultural Officers who are in intimate association with the research officers have twofold functions to perform, namely, putting to test on a field scale the improvements suggested at Coimbatore and at other Research Stations, in places which may at times be dissimilar in soil and climate and investigating the various local problems in farming practice.

To translate the results of research into the cultivators' fields, there is the district staff of demonstrators and their subordinates under the supervision of the District Agricultural Officers. They educate the farmers in the new methods and persuade the latter to adopt them. Steeped in tradition and by nature disinclined to take up to a system to which he is unaccustomed, the ryot is naturally cautious and quite rightly wants to be convinced of the reliability and efficacy of the new practices suggested by the department before he is willing to adopt them. The experimental stations by themselves do not impress him, since he has neither the background to appreciate or grasp the technique of experimentation nor the equipment to assess the need or scope for

advance through scientific methods. Most of the ryots are illiterate and publications on agricultural subjects can but affect only a small section. It is necessary, therefore, to go to the ryot to demonstrate and persuade him, rather than wait for him to come for his personal edification. Agricultural exhibitions are held with the above intention on all important occasions and festivals at which the rural folk congregate.

The general policy is to begin with simple improvements and direct demonstrations wherein the improved and existing practices are displayed side by side. The ryots are given a chance to observe for themselves the really effective departmental methods and this serves to gain their confidence. The next step is to lead the ryots step by step till all that has to be taught is fully demonstrated. Perhaps the most occular and effective demonstration is that of an improved strain alongside the commonly grown crop. The practical ryot is quick to notice the difference and it does not take long for him to supplant the old by the new. There is a long list of other improvements that require demonstration, affecting every aspect of agricultural life, from the use of a tool or implement to that of effective manuring, control of pests and diseases, better agronomic practices, economic methods of storage of farm produce, methods of disposal and utilization of farm wastes and the like.

The application of the results of research in the field is not solely dependent on the capacity of the demonstrator or the number of extension workers. The ryots' response is to a large extent influenced by his financial ability to carry out the improvements. To be effective, research must, therefore, be shaped so as to evolve improvements that will not merely be effective in upgrading agriculture but also be within the reach of the vast majority of farmers who are in the lower economic groups. A five per cent reduction in seedlings by adjustment of spacing in the field may lead to greater benefit than effecting economy in fuel consumption in a high-powered tractor. While both these types of improvements are essential, it is not desirable to belittle the significance of improvements on items that may appear minor but which sometimes affect the lives of the largest bulk of our ryot population. The work described in this chapter has to be appreciated against such a background.

The various items of propaganda and extension work carried on by the department is described in detail in the following paragraphs. Of late, it is realized that departmental extension work has to be broad-based by enlisting non-official co-operation in a more active manner than in the past. Appointment of honorary extension service workers from among the leading non-officials has already been sanctioned by Government. Establishment of model farms and orchards by the Government and by selected non-officials has been accepted as a potent method of carrying conviction to the ryots. Broadcasts on agricultural subjects in simple and popular language are found to be a very effective means as the number of

community radio receiving sets increase in our villages. The medium of the cinema has not yet been employed to any appreciable extent for educating the masses in matters agricultural, but is one that is likely to play a more vital part in the future. Methodology in extension work is acknowledged to be of supreme importance, and with the gradual extension and reorientation of our extension service, the existing gap between research and the ryots' field is bound to be filled up and led on to sustained agricultural prosperity.

I. *The administrative set-up.*—The Agricultural Department is under the control of the Director of Agriculture and he is assisted by two Deputy Directors at headquarters for guiding the agricultural propaganda work in the districts. The State is at present divided into eight circles of 2 to 4 districts each and each circle is in charge of a Regional Deputy Director of Agriculture. There are District Agricultural Officers, each in charge of a district and the Taluk Agricultural Demonstrators work under them. The Agricultural Demonstrators are the officers who do agricultural propaganda work in the village and carry out practical demonstrations of agricultural improvements. All the taluks have been provided with Agricultural Demonstrators and some of the heavy taluks have two demonstrators. Mycological and Entomological Assistants are also stationed at district headquarters for attending to plant protection work. The demonstrators are assisted by fieldmen and demonstration maistries. The fieldmen are generally of the fourth form standard and are used for running demonstration and trial plots and for attending to similar items of work. They are employed at the rate of one for every two to four firkas, depending upon the development and intensity of the work turned out. The demonstration maistries are literate men who actually demonstrate the improved implements, sowing, putting up manure pits, etc. They are employed at the rate of one per firka. How the agricultural propaganda work is being done is indicated in the subsequent sections.

II. *Methods of propaganda and publicity*—(i) *Propaganda*—(a) *Agricultural Demonstrators.*—Improvements in the several aspects of farming and cultivation are worked out at the various Agricultural Research Stations in the State and the Agricultural Research Institute at Coimbatore. These are passed on to the cultivators in the State by the propaganda staff. The Agricultural Demonstrator is an agricultural graduate and serves as the chief connecting link between Research stations and cultivators in the dissemination of agricultural knowledge and improvements in the villages among the cultivators. He is assisted in this work by fieldmen and literate demonstration maistries who have been given preliminary grounding in the improved methods of cultivation at the Agricultural Research Stations.

The actual cultivators in the village are generally not literate, but are well-versed in the art of cultivation. This knowledge has been passed on to them in a thumb rule manner by

generations of cultivators before them, and has been acquired largely by trial and error. They are generally conservative to a degree and do not easily take to changes in the methods of cultivation, unless it is proved to them beyond any shadow of doubt. Even then their response is conditioned by the availability of ready means to take up the improvements. The Indian cultivator is proverbially poor and profitable improvements which he might otherwise take up, do not therefore often become useful to him. It is under these conditions that the Agricultural Demonstrator has to do his work, and he is judged not by the extent of actual work done by him, but by the extent of the improvements taken up by the cultivators. This is an unusual standard and the Agricultural Demonstrator's work may not in all cases be appreciated fully and he may not be given the credit due, because of the type of scale with which he is measured.

The Agricultural Demonstrators visit the taluk villages, study the various factors that influence agriculture and chalk out programmes of improvement work to be carried out in the several regions of the taluk. These programmes are scrutinized and suitably modified by the District Agricultural Officers. The programmes indicate the strains proposed to be spread, the several improvements that are to be effected and the targets under each. The several improvements programmed are later introduced in the villages by the demonstration staff. The individual cultivators are met singly and in groups and the improvements programmed are explained to them and they are persuaded to take them up. It is slow work and depends to a large extent upon the frequency of contacts made, the strength of the demonstration staff and their persuasiveness, zeal and enthusiasm.

The demonstration staff could not contact directly all the cultivators in the villages and various methods of effectively carrying out improvements in the villages have been tried, with varying results. The demonstrators were contacting originally a few selected cultivators in a few villages in the different parts of the taluk and attempting to effect improvements in their cultivation methods with the object of making the improvements spread out in a natural way. The villages were far apart, the contacts with the cultivators were not frequent enough and the work done was not impressive. From 1931 onwards the Agricultural Demonstrators concentrated their work in a few centres, with a few villages adjoining each centre. When these centres got familiar with the improvements suggested by the demonstrators, the centres were changed and new centres were taken up for concentrated work. This system limited the departmental activities to a few centres and villages. This also was not satisfactory, and the Demonstrator's activities were later dispersed over the entire taluk as was done originally.

The demonstration maistries were originally drawn from the labouring classes in the villages, as they had a background knowledge of practical agriculture. They were, however, found to have poor persuasive powers. In 1935, literate men were first

recruited as demonstration maistries for trial in Visakhapatnam district. They were made to live in the villages away from the taluk headquarters and this facilitated a greater contact between them and the cultivators. Literate demonstration maistries are now recruited and given some training at the Agricultural Research Stations to enable them to do their work efficiently. This has been satisfactory.

(b) *Trial plots.*—When a certain strain of a crop or a certain cultural or manurial method has been tried at an Agricultural Research Station and is proved to be better or a definite improvement over the cultivators' practice, it is tried in ryot's lands under village conditions in what are called 'Trial Plots.' The local method is also tried side by side. The results of a number of trial plots spread over a number of villages and over a few seasons, are analysed and studied. If then, the new method is found to be a definite improvement, it is advocated to the cultivators for adoption. Such tests enable really better methods being selected, eliminating the effects of extraneous factors as the fertility of a piece of land, the influence of climate in a year, etc.

Observation plots.—Trial plots laid out without strict reference to conditions governing the technique of modern field experiments are termed as "Observation Plots". Although results based on statistical analysis cannot be secured, it is possible to draw rough and ready conclusions from the results obtained in "Observation Plots" provided they are calculated from a fairly large number of plots.

(c) *Demonstration plots.*—When a particular improvement has been passed through the stage of trial plots, it is demonstrated in big size plots in ryot's lands in what are called 'Demonstration Plots'. The cultivator is thereby enabled to see the improvement and compare it with his own method. This carries conviction and the ryot naturally adopts the improvement. Several items of improvements like new strains of seeds, cultural practices, manurial methods, conservation of cattle manure, green manuring and others are thus demonstrated in a large number of plots in the different tracts every year. These gradually become part and parcel of the ryot's practice. Several improvements have been so passed on to the cultivators and the help and guidance of the Agricultural Officers is sought by the cultivators in an increasing manner.

(d) *Demonstration farms on ryots' lands.*—Demonstration farms were run for three years from 1924 in ryots' lands in North Arcot, South Arcot, Chingleput and Chittoor districts. Ryots cultivated ten acres of their land as suggested by the Agricultural Departmental Officers, carrying out all the improvements suggested and cultivated an equal area in the usual way as they were doing before. The Department supplied seed free of cost in the case of new varieties and new crops, and also manures free of cost when special manures were suggested. Other expenses were borne by the cultivators themselves. The cultivators were promised to be compensated in the case of failure of any of the improvements advocated.

The use of improved ploughs, green manures in combination with fish guano, thin paddy nurseries combined with economic planting and improved strains of paddy were demonstrated in wet land areas. Commercial crops like sugarcane and groundnut were introduced in the rotation of irrigated dry lands (garden lands) and the use of drills for sowing and improved ploughs for preparing dry lands were demonstrated. Detailed accounts of the cost of cultivation and receipts were maintained.

Subsequently individual landholders and co-operative societies were encouraged to conduct demonstrations along similar lines. The department lent improved implements for preparing the land and supplied free of cost new seeds and manures.

It was expected that under this arrangement the cultivators of the locality would see the improvements and copy them, that they would serve as demonstration farms for the Agricultural Department at a negligible cost, and that the cultivators concerned would get the benefit of the improvements. There was lack of enthusiasm among the cultivators and the scheme was not continued.

(e) *Agricultural Associations.*—The formation of Agricultural Associations for disseminating agricultural information and demonstrating improved methods of agriculture was encouraged from the early days of the Agricultural Department. Associations were formed at village, taluk and district levels in a number of places. A few of the associations undertook the demonstration of improved agricultural methods, while the majority did not function at all. Government promised financial assistance to associations that undertook specific agricultural experiments approved by the Agricultural Department. But even this did not help and Agricultural Associations have not come up to expectations.

(f) *Exhibitions and shows.*—Exhibitions and shows are conducted by the Agricultural Department during festivals and fairs, where people gather in large numbers. One or two big district exhibitions and some small taluk exhibitions are generally arranged every year in all the districts, and the various activities of the Agricultural Department are publicized various improved strains suitable for the locality, improved implements, manures, insecticides, and live specimens of fodder grasses and green manures are exhibited. Posters and charts on various agricultural topics are put up and the exhibits and charts are explained to the visitors. Leaflets are distributed to the public free of cost in large numbers. The use of improved ploughs, sprayers, dusters and various machinery is demonstrated in the exhibition grounds, wherever facilities for such demonstrations exist.

(g) *Motor exhibition vans.*—Two motor vans were fitted with exhibits in 1928 and taken to the interior villages. A third van, presented by a Tanjore mirasdar, toured in the districts of Tanjore, Tiruchirappalli, Madurai and Tirunelveli. The itineraries of the vans were notified in advance and exhibits arranged in

the vans were kept on show at each place for a few days. Agricultural demonstrators toured with the vans and explained the exhibits to the people visiting them. Magic lantern lectures were arranged to be delivered in the evenings at the several places. The exhibitions vans and the magic lantern lectures attracted the people from the surrounding villages and provided useful entertainment and much agricultural knowledge. The vans became unserviceable and were discarded in 1938.

One motor van with electric projection equipment and agricultural films was purchased in 1949 and has been touring in firka development centres doing useful work.

(*h*) *Co-operative Agricultural Societies.*—A number of agricultural improvement and loan and sale societies have started with the help of the Co-operative Department. These societies help the members in the purchase and sale of seeds, produce, manure and agricultural requisites. A few societies maintain breeding bulls for serving the cows owned by members. The loan and sale societies maintain warehouses and advance cultivation loans to the members on the pledge of the standing crops and produce loans on the pledge of the produce kept in storage in the godowns of the societies. The Lalgudi Sivagnanam Co-operative Society owns an agricultural farm and multiplies improved strains of seeds for its members and demonstrates agricultural improvements.

(*i*) *Prizes.*—Ploughing competitions with mould board ploughs were held in 1924 and Government awarded prizes aggregating to Rs. 20 at each such competition, with the object of popularizing mould board ploughs. Iron ploughs, improved strains of paddy seeds, and fertilizers were given away as prizes. All these have helped in popularizing mould board ploughs in the country. They have become popular and large numbers of iron ploughs are now made by Indian firms and sold to the cultivators.

(ii) *Publicity*—(*a*) *Villager's Calendar.*—This is published annually by the Agricultural Department to serve as a book of reference for the cultivators, in the regional languages, Tamil, Telugu, Malayalam and Kannada. An English edition was also being published but has been discontinued from the year 1949. The calendar publishes district notes on the agricultural improvement work in the several districts, the crops grown, the strains of crop found suitable, the location of agricultural depots, the facilities afforded by the Development departments relating to health, cooperation, cattle diseases control, fisheries, etc.; notes on important agricultural subjects, almanac, lists of fairs, festivals and shows in the several places and other relevant material are also furnished.

(*b*) *Leaflets.*—Short notes on agricultural improvements, the cultivation of new crops, etc., are prepared in English and the regional vernaculars in the form of leaflets and widely distributed among the people, free of cost, with the object of popularizing the particular improvement or cultivation. The distribution is done when cultivators go to the depots, and the Departmental staff

visit the villages and at the time of the exhibitions and shows when a large number of people congregate. These leaflets have been very helpful in disseminating agricultural information widely and there is a definite demand for such publications.

Detailed information on specific subjects are also provided by small booklets or bulletins, which are generally priced publications. The demand for bulletins is limited and confined to educated people who are interested in the particular subjects dealt with.

(c) *Agricultural digest and press jottings.*—A monthly digest giving the salient features of the work of the department was issued from 1922 onwards with the object of popularizing the departmental activities. This was made a quarterly digest from 1929 and discontinued in 1932 as a measure of retrenchment. But periodical jottings and short press notes were published in the newspapers, instead.

(d) *Scientific publications.*—Interesting and valuable scientific notes of research are published by the various workers at the Agricultural Colleges and Research Stations in journals like *Current Science*, The *Proceedings of the Indian Academy of Sciences*, *Indian Farming*, *Madras Agricultural Journal*, etc. The *Madras Agricultnral Journal* is published by a band of honorary workers recruited from the Agricultural College and the Research Institute at Coimbatore, under the auspices of the Madras Agricultural Students' Union.

(e) *Grow More Food Journals.*—When the various Grow More Food Schemes were launched in 1944, two vernacular journals called "Mezhichelvam" in Tamil and "Padi Pantalu" in Telugu were started. They are departmental journals popularising the Grow More Food schemes and the activities of the Agricultural Department. Articles on rural development, co-operation, village sanitation and cattle diseases are also included and the journals cater directly to the village cultivators. The journals were issued free in the beginning and 5,000 copies in each of the languages were issued. As the journals were popular the number was increased to 10,000 in 1945. Later a nominal price of one anna per copy was levied from April 1949. Two more journals, one in Kannada called 'Krishika Bandhu' and another in Malayalam called 'Naveena Karshakan' were published in 1949. The journals are very popular and serve as a suitable medium for spreading agricultural knowledge and information about agricultural improvements among the cultivators. They are in great demand and there were 1,15,000 subscribers for Telugu, 33,500 for Tamil, 9,000 for Kannada and 5,500 for Malayalam journal on 1st July 1950.

(f) *Radio talks.*—Interesting and useful information on various agricultural subjects is being systematically broadcast through the All-India Radio broadcasting station at Madras, Vijayavada, Tiruchirappalli and Kozhikode, in the several regional

languages. A wide range of subjects is covered by the talks, like food production, manuring, tree planting, fruit culture, vegetable cultivation, reclamation of soils, co-operative farming and so forth.

III. *Grow More Food Schemes*—(i) *Seeds*—(*a*) *Seed farms*.—When the improved strains establish their superiority over the local varieties in trial and demonstration plots, they are multiplied for distribution to ryots in a large scale. The multiplication of the seeds is done in seed farms. The seed farms are lands owned by cultivators who agree to cultivate the strains given to them and adopt methods of cultivation recommended by the department and maintain the purity of strains by removing those crop plants that are not true to the type with the help of departmental staff and thrash and preserve the seeds in such a manner that they are not contaminated by other types of seeds at the thrashing floor, the storing receptacles and the store room. These seeds are well dried before storage, so as to ensure that the vitality of the seeds is retained. Later the department purchases these seeds at rates that may have been fixed originally at the time the seeds were issued to the ryots and an agreement entered with him for the fulfilment of the several contractual obligations by both the ryot and the Department. The price paid for the seed is higher than the market price by a certain pre-determined margin, usually a percentage of the market price. The higher price is paid to serve as an inducement to the ryot to take up seed multiplication work and to compensate for the trouble taken by him to guard the purity of the seed stock, as well as its quality.

The details of running the seed farms have been varying, but the main principles underlying the running of the seed farms have been the same from the time seed farm work was commenced in the earlier years of the Department.

The seed farm seeds are later sold to the ryots. These improved seeds are in good demand and are popular with the cultivators. Cultivators visiting the depot for the purchase of seeds has now become a common feature. Apart from this, the improved seeds with the cultivators are also purchased by the neighbouring ryots who would have been noting the performances of these strains in the preceding years. Considerable spread of the improved strains has also taken place in this manner and this method of spread may be called the 'natural spread' of the strains.

(*b*) *Intensive seed distribution schemes*.—India was importing food grains even before the second world war. She was importing large quantities of rice from Burma and Siam. These sources were cut off after the fall of Burma into Japanese hands. The insufficiency in local production of foodgrains began to be felt by the various administrations, and the general public. The importance of agriculture in national affairs and the prominent part played by the cultivators in shaping the destiny and economy of the country were clearly perceived, in a manner not likely to be forgotten by the people.

It was then that large scale plans were drawn up for stepping up food production. The Central Government took the lead and came forward to subsidize production of food in various ways and to co-ordinate the activities of the several member-States in this regard. A comprehensive scheme of agricultural development was sanctioned in 1944 and put into operation immediately. One of its important branches was seed development work. Seed farms were arranged in large areas and the seeds obtained were distributed to ryots for seed purposes for covering extensive areas. The basic assumption was that improved strains of seeds helped to give 10 to 15 per cent more yield than the local varieties and if the whole country were to be sown with improved strains of seeds, then the ovel-all increase in production could not be negligible.

In 1947, a new five-year plan was brought into operation, and the several schemes under the original comprehensive scheme were merged in this plan. Again in 1948, when the Prime Minister of India announced that India would stop importing food-grains by the end of 1951 and that India should become self-sufficient in the production of food, a new two-year plan was drawn up and put into operation from 1949–50. The two-year plan has since been made into a three-year plan. The different targets of production originally aimed at were not achieved in full during 1949–50 due to the very bad seasonal conditions during 1948–49 and 1949–50. The north-east monsoon on which a large measure of cultivation of crop depends failed in the southern districts of the State during both the years. There were cyclones in the northern districts which spoilt the standing crops and certain cultivation areas.

The qauntities of improved seeds distributed from the inception of the comprehensive scheme are given below :—

Name of seed.	1944–45 (*tons*).	1945–46 (*tons*).	1946–47 (*tons*).	1947–48 (*tons*).	1948–49 (*tons*).	1949–50 (*tons*).
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Paddy	9,317	9,046	12,540	9,030	7,934	6,012
Millets	..	146	56	984	84	104
Pulses	141	382	19	..	3	1
Other seeds including green manure seeds ..	1,102	1,265	42	65	2,634	1,015

(c) *Free distribution of seeds to poor and deserving ryots.*— As a Grow More Food aid, seeds valued at Rs. 100 were issued to poor and deserving ryots in each district during 1944–45 and continued every year till November 1948. The free issue of seeds was liberalized considerably during 1945–46 in the cyclone-affected areas in Visakhapatnam, East and West Godavari, Krishna and Guntur districts. 13,397 ryots were supplied with 121 tons of paddy seeds.

(ii) *Manures—(a) Farm-yard manure.*—Intensive propaganda on the proper method of preservation of farm-yard manure and practical demonstrations are being carried out in the villages from the early days of the Department. The importance of collecting

cattle urine and preserving it properly is also stressed. The ryots are persuaded to collect, store and preserve the manure properly in pits, and loose boxes. For instance during the year 1948–49, 50,662 new manure pits were dug and 73,682 old pits were renovated. The loose box system of tethering cattle and preserving the manure under the feet of cattle was introduced in 1,752 holdings.

(b) *Green manures.*—Growing leguminous crops in the field and ploughing the crops into the soil is an easy method of enriching the soil and increasing the proportion of organic matter or humus. Growing green manures as a catch crop in between main crops is being recommended to the cultivators. There are a number of suitable crops to choose from. *Kolingi* or wild indigo comes up well in light soils and needs no care practically. Daincha, and *pillipesara* are suitable for the heavy soils. Daincha is also suitable for alkaline soils. As a result of the intensive propaganda done by the Department over a series of years, growing green manure crops has become a standard practice with many ryots in the several areas of the State, wherever facilities exist. Green manure seeds are being arranged to be produced in suitable areas and these are later distributed all over the State, through departmental agency and assistance. Wherever facilities exist, water is supplied from the several irrigation systems for the cultivation of green manure crops, without any extra assessment or water rate being levied.

One of the handicaps of the Grow More Food campaign has been the limited supplies of nitrogenous manure like oilcake and fertilisers like ammonium sulphate in the country. In view of this it was considered necessary to intensify green manuring. From 1946 onwards green manure seeds were produced in large quantities and made available to the ryots for sowing. The area under green manure crops consequently increased and it has been estimated that green manures were sown in 117,900 acres during 1948–49 with seeds supplied by the Department. Local production of seeds and supply have been going on side by side. But still there are large areas where green manure crops could be grown advantageously.

Green manure crops.—A number of green manure crops are commonly grown. Their relative distribution is regulated by their suitability to the soil and climatic conditions ruling in the several localities, and ease of availability and cost of seed material. The general guidance that can be given is that the particular green manure crops that comes up best in the locality should be chosen for cultivation. As between crops that come up equally well, the preference should be for that crop that gives more green matter per acre. The richness of the material and the ease with which the green matter decomposes in the soil are also relevant matters, but these are subsidiary considerations only taking rank after suitability to the region and yield or tonnage.

The manurial value of green leaf manures.—Experiments conducted in 1948–49 show that on an equal nitrogen basis green manures are two-thirds as effective as ammonium sulphate in increasing paddy yields. The green manure had a direct manurial value in paddy lands; there was an actual increase in the nitrogen content in the plots manured with green manures.

Green leaf manures.—When plants are raised and ploughed into the field, it is referred to as 'green manuring'. When green leaves are obtained from other sources and applied to the field, it is called 'green leaf manuring.' Intensive efforts were made to induce the people to grow green leaf yielding trees and shrubs on field bunds, tank bunds, channel bunds, porambokes and all vacant sites. Seeds, seedlings, stem cuttings and stumps of several suitable plants were distributed in large numbers. They included neem, *pungam*, glyricidia, *konnai* of different kinds, *poovarasu*, *malai poovarasu*, etc. A total of about 70 lakhs of such kinds were issued in 1948–49.

(c) *Composts.*—The organic matter in tropical soils is proverbially low. The high temperature that prevails aids the rapid destruction of the organic matter in the soil by oxidation. It is very necessary therefore that organic matter should be added to the soil to the largest extent possible. Cattle manure is produced only in limited quantities. Green manures could be grown. There are also other organic wastes like crop residues, farm wastes, sweepings from municipalities and so forth which could all be converted into suitable manure by decomposing them. The decomposed material is called compost. The organic wastes alone referred to are not all utilised fully for use as manure. Composting them will help in increasing the supply of manures. Considerable stress has been laid on this from the time of the inception of the Grow More Food schemes and cultivators are advised to make use of the composts in a proper way.

Town compost.—The street sweepings and collections from garbage bins in municipalities and panchayats are composted along with the collections of human faecal matter. The compost made with a mixture of human faeces and municipal rubbish is a fine brownish friable mass, which easily crumbles into a powdery material and is free from any objectionable odour. Most of the municipalities compost the sweepings and night soil, and distribute the compost to the cultivators at reasonable rates fixed by the Government. The selling price of compost was fixed at Re. 0–10–0 per cart-load during 1949–50. The quantity of compost made by 51 out of 75 municipalities and 35 panchayat boards in the State during the period was 103,389 tons. The making of compost is supervised by sanitary inspectors trained in compost making. The composting process is checked periodically by the Agricultural and Health Department Officers, and defects noted are rectified then and there.

Rural compost.—As the manures available in the country were in short supply, an intensive drive was launched from 1945

to induce the cultivators to take up the making of compost in villages, with various crop residues and other organic wastes available in the farms using cowdung, urine earth and wood ash as the starter material. Compost pits were dug in the villages and compost making was demonstrated widely.. The making of rural compost was subsidised and this has been a real inducement with the result that compost making is becoming a comon feature in the villages. During 1949–50, a quantity of 64,716 tons of ripe compost was prepared from waste vegetable matter in the villages. The cultivators were paid a subsidy of Re. 1 per ton of compost made. It has been estimated that 40,445 tons were applied over 8.089 acres and that 1,011 tons of additional foodgrains were produced.

(*d*) *Purchase and distribution of manures.*—As a result of the war, the import of grain and manure was affected and the prices of agricultural produce tended to rise by 1943. The cultivators got manure-minded and there was a heavy demand for the manures available in the country and its availability was limited. Consequently the prices of manure tended to shoot up abnormally and Government had to intervene. The Manure Dealers' Licensing Order of 1943 was promulgated and the manure dealers had to take in licences for dealing in manures. The movement of manures was controlled and ceiling prices were fixed for the different classes of manures. Manures, iron and steel, the primary agricultural necessities were taken over by the Agricultural Department and distributed under the State Trading Schemes. This had the desired effect. The prices got stabilized and distribution was made in a fair and equitable manner.

The important manures dealt with under the State Trading Schemes were groundnut cake, ammonium sulphate and phosphates. Export of groundnut cake to places outside the State was prohibited and imports from surplus States like Kathiawar and Hyderabad were encouraged. The available manures were sold to the ryots in an equitable manner on a subsidized basis. The overhead charges connected with the movement and storage of manures up to a limit of 10 per cent of the cost was met by the State Government and the Centre on a 50 : 50 basis, as also the entire establishment charges. Originally 50 per cent of the groundnut cake produced in the mills was taken over by the Department for distribution and the other 50 per cent was allowed to be distributed by the normal trade channels at controlled rates. As it was observed however, that the trade indulged in questionable and unfair methods of sale, the Department took over the entire production of cake from July 1946 for distribution through the Agricultural Department Depots. These restrictions were partly relaxed in January 1948 and 40 per cent of the cake produced was allowed to be distributed through normal trade channels. Later the price control was removed in July 1948 and the distribution of the cake was transferred from the Agricultural Department to the co-operative societies.

The quantities of manures and fertilisers sold during the period when the State Trading Schemes were in operation are indicated below :—

Year.	*Oil cakes.*	*Ammonium sulphate.*	*Phosphates.*
	TONS.	TONS.	TONS.
1944–45	62,257	16,717	1,409
1945–46	117,045	13,904	1,761
1946–47	237,865	24,080	2,107
1947–48	203,426	23,390	2,990
1948–49	28,816	29,684	..
1949–50	..	59,952	16,210

The question of controlling fertilisers and adulteration of the malpractices by the trade were under the consideration of the Government of India and the various provincial Governments from the year 1919. Though the need for safeguarding the interests of the consumers by legislative means was accepted, effective measures were not taken on account of the cost of enforcement of such legislative measures. In 1949 however, the need for taking effective measures was accepted and the Madras Government decided to take effective measures to control the quality, prices and distribution of straight fertilisers and fertiliser mixtures. It was thereafter made obligatory for manure firms to take out licences for preparing mixed fertilisers, and for dealers who distribute the fertilisers. They are required further to exhibit the composition of the fertilisers and to have the selling prices of the fertilisers approved by the Director of Agriculture.

(*e*) *Scheme for the popularization of phosphatic manures.*—The South Indian soils are deficient in phosphoric acid and this deficiency is one of the causes of the low yields in the country. It was considered necessary that the cultivators should be made conversant with the use of phosphatic fertilisers and the benefits of such fertilising and the Madras Government arranged to demonstrate and distribute 100 tons of super phosphate and 100 tons of bonemeal at half the cost price during the year 1946 in Tanjore, Krishna, Guntur, Godavari and Madurai districts. Half the cost of the manure treated as a subsidy was shared by the Madras and Central Government on a fifty fifty basis. The scheme was later enlarged and the entire quantity of phosphatic manures distributed in the State was sold at half the cost price, the balance being treated as subsidy by the State and the Central Government. This has been very helpful in popularizing the use of phosphates and the cultivators have begun to realize the value of phosphatic fertilisers and are keen on applying them to their paddy fields.

(*f*) *Free distribution of manures to poor and deserving ryots.*—The object of the Grow More Food Schemes is to increase production and one of the factors standing in the way of increasing the production has been the poverty of the poor cultivators. From 1943 onwards, the Government have been granting Rs. 2,000 in each district towards supply of manures free of cost to poor and

deserving ryots. This has been enabling them to manure their field and increase the production from land which may not have been possible otherwise.

Free distribution of manures in Malabar and South Kanara districts.—During early 1946, the food situation in Madras was very critical and concentrated efforts were made to increase production in the region where paddy was raised earliest in the season, i.e., in the taluks of Palghat and Walluvanad in Malabar district and Kasargod of South Kanara district. Twenty-eight thousand two hundred tons of groundnut cake and 7,050 tons of ammonium sulphate were supplied free to rice cultivators in these areas for application to the short duration first crop of rice. It was estimated that by this at least 50,000 tons of additional rice was made available to the country though at a great cost on the exchequer.

(iii) *Controlled distribution of iron and steel.*—As a result of the war; the supply of iron and steel was very restricted and the cultivators experienced considerable difficulties in getting their requirements of tools, implements, cart tyres, etc. Iron and steel supplies and distribution was controlled by the Government and equitably distributed for the various purposes. The iron and steel required for agricultural purposes was acquired and distributed by the Agricultural Department. The raw material was allotted to approved fabricators for being made into tools and implements and these were distributed to bona fide ryots and cultivators in an equitable manner.

In addition, petrol pump sets, crude oil engines, electric pumps and motors were also distributed to the cultivators by the Department, both for hire and sale. Tractors with ploughs and bull dozer attachments were acquired and let out for hire at concessional rates for ploughing uncultivated fallows, for bringing new lands under cultivation, for clearing shrubby growth and levelling uneven terrain. An engineering section was formed and supervisors, mechanics, fitters and drivers were stationed at the various district headquarters to cope with the work connected with the running and maintenance of the pumps and tractor units. These mechanised equipment save considerable labour and cost and are particularly valued as bullock and human labour have become costly. They are in very great demand and it looks as though mechanised equipment have a place in South Indian agriculture and that they have come to stay.

(iv) *Special extension courses.*—The crops and soils wing of the Board of Agriculture and Animal Husbandry in India recommended in 1942 at its fourth meeting that the Agricultural Education of farmers should be carried out by means of special extension courses, to supplement the propaganda and demonstration done by the staff of the Agricultural Department and should be imparted by staff specially equipped for the purpose. Accordingly the Madras Government have been selecting ten farmers in each

district and taking them on a short tour to a few Agricultural Research Stations and private farms in other districts at State expense. Selected Agricultural Demonstrators accompany them, show them the salient agricultural features of the several places they visit and discuss the variations in the agricultural practices so as to serve as a sort of education and stimulus and to create a desire for acquiring knowledge. The farmers who have been given these facilities have been immensely benefited, Some of the more enthusiastic try the several improvements seen and that have appealed to their fancy and method of thinking, in their own land and farms. It is no doubt a healthy awakening. The farmers know their problems and they strive to find out whether anything that they see could assist them in solving their own problems. These extension courses have their own limitations, but are none the less useful.

(v) *Takkavi loans.*—Loans were being granted by Government to ryots for improving the land, for fitting up agricultural machinery and for similar purposes. The loan rules were liberalized in 1933 and the Agricultural Department was entrusted with the work of granting loans free of interest up to Rs. 80 per applicant for the purchase of seeds and manures and Rs. 100 for the purchase of implements, and Rs. 250 for grants in the Nilgiris district only. These loans are repayable in two annual instalments along with the land assessment and are collected by Revenue Officials.

The amounts allotted for the grant of loans were limited originally, but large amounts were ear-marked for this purpose from 1943 onwards with the object of furthering the Grow More Food Campaign, and a large number of ryots took advantage of the facilities provided. The amounts distributed as loans during this period is an indication of the popularity of these loans, as shown below :—

Year.	*Loan granted.*
	RS.
1944–45	**21,28,304**
1945–46	**41,33,734**
1946–47	**50,30,725**
1947–48	**19,78,318**
1948–49	**7,99,897**
1949–50	**28,70,404**

During July 1950, a sum of Rs. 60 lakhs was set apart for grant as special loans for purchase of fertilisers like ammonium sulphate and superphosphate for manuring the first crop of paddy at Rs. 25 per acre limited to Rs. 200 per applicant. The loans were made repayable in one instalment without interest before the end of the official year in March 1951. The loans were made available to cultivating tenants also who were able to secure surities. either the owners of the lands themselves or others. The scheme contemplated the distribution of one lakh tons of ammonium sulphate for manuring the first crop of paddy in regions of assured water-supply in Godavari, Krishna, Guntur, Nellore, South Arcot,

Tanjore, Tiruchirappalli, Madurai and Tirunelveli districts. This intensive distribution was expected to give an additional yield of two lakh tons of cleaned rice and help to wipe out a large part of the normal deficit of 6½ lakhs of tons in the State. The estimate of increased production is based on the large number of experiments carried out in Agricultural Research Stations and trial plots arranged in cultivators' fields. It is proposed to guage the actual increase in yield by harvesting a large number of samples of manured and unmanured fields all over the State during the season. and prove to the skeptics that large scale and country-wide increase in yield could be brought about by the adoption of suitable fertilising methods.

(vi) *Land development work—(a) Cauvery-Mettur Project area.*—Out of an extent of 301,000 acres proposed to be brought under irrigation under the Cauvery-Mettur project, a large area remained unirrigated. On examination it was found that the reasons for the non-development of irrigation in this area, were mainly lack of labour, want of irrigation facilities such as field *bothies*, etc., disputes between land-owners and tenants regarding payment of rent and want of capital. In order to remedy these and in furtherance of the Grow More Food Campaign, the Government of Madras launched a scheme that aimed at bringing under irrigation an extent of about 40,000 acres of commandable but unirrigated land in the Cauvery-Mettur project area, as a first instalment.

A special revenue staff was appointed to investigate the causes of non-development of irrigation and to settle the disputes between the land-owners and tenants amicably. Public Works departmental staff was employed specially to provide the necessary irrigation facilities and to reclaim the Government-owned waste lands. A special Agricultural staff advised the ryots on reclamation of lands and bringing them under rice cultivation. The cultivation of green manure crops in the Cauvery-Mettur project area was made compulsory by executive orders issued by Government. Eight thousand bags of green manure seeds were distributed free to the ryots and sown in about 50,000 acres, with the help of the Agricultural department in 1945. During subsequent years, the ryots sowed green manure crops regularly in rotation and the department arranged supply of the required quantity of green manure seeds. Suitable departmental rice strains like ADT 3 and ADT 20 for *Kuruvai*, ADT 2, ADT 8, CO 19, CO 25 and CO 26 for *samba*, and *thaladi* crops were introduced and seeds were made available to the ryots by the department. Consequently the entire area of 301,000 acres under the Cauvery-Mettur Project has only the improved strains of rice referred to. Oil cakes and chemical fertilisers were also supplied to the ryots in large quantities by the department and got reflected in increased rice yields. The ryots realized the advantages of manuring and manuring rice lands has became a regular feature. As a result of the co-ordinated

efforts of the Revenue, Agricultural and Public Works departmental activities, 60,157 acres were reclaimed in the Cauvery-Mettur Project area within an year. Out of this, 52,224 acres were brought under rice cultivation.

(b) *Wynad colonization scheme.*—Large stretches of land in Wynad in Malabar were lying uncultivated and Government selected this area for forming an ex-service-men's colony in 1943. The land for the colony was acquired, surveyed, demarcated and laid with suitable roads in 1944. Anti-malaria operations were also undertaken. It was then proposed to settle 3,500 families of ex-service men and local inhabitants in an area of 27,000 acres of dry land and 7,000 acres of wet land by allotting 5 acres of dry land and 2 acres of wet land for each ex-service man and setting apart grazing and forest areas for the use of the community in common. The ex-service men were also to be given advances up to Rs. 1,900 each for starting the cultivation and sustaining himself in the initial stages. Settling people in the colony was started in March 1948. By April 1950, 760 ex-service men and 1,000 local inhabitants were settled in the colony.

An Agricultural Research Station was started in Ambalvayal in the scheme area in 1945 to explore the agricultural possibilities. Varietal, manurial and cultural trials on rice, sugarcane, *ragi*, sorghum, *bajra*, setaria, groundnut, gingelly, horse-gram, red-gram, cow pea, wheat, chillies, ginger, turmeric, potato, barley, betel vine, fodder grasses, eucalyptus and fruit trees commenced. Some varieties of rice have been found to be suitable for the tract. CO 419 sugarcane does well as a rainfed crop and gives up to 40 tons of cane per acre standing in the field for 12 to 14 months. *Ragi* comes up well, but not the other millets tried. Tapioca, sweet potato, yam, colacasia, edible canna and arrowroot do well as seasonal dry crops. Ginger, turmeric and chilly thrive well in Wynad. Malta lemon, passion fruit, pine apple and cape gooseberry appear to be suitable for the tract.

On the demonstration side, the settlers are advised on the choice of crops, their cultivation, the preservation of cattle manure, soil conservation, control of pests and diseases, etc.

(c) *The Araku valley scheme.*—The Araku Valley Scheme was started in 1944 with the object of producing potato and other exotic vegetables for supply to the military personnel stationed at Visakhapatnam, developing potential lands in the hill agency areas of the Visakhapatnam district and raising the level of agricultural economy of the hill tribes, starting with the Araku valley as the nucleus.

During 1944, 1945 and early 1946, potato and exotic vegetables were grown in the Araku valley and supplied to the army. The profitable cultivation of these vegetables was successfully demonstrated to the people. Potato, cabbage, cauliflower, knol-khol, turnip, carrot, tomato, beans, etc., were all grown successfully. Indigenous vegetables like ladies fingers, brinjals, gourds, cow pea, etc., were also grown and supplied.

An Agricultural Demonstrator and maistri were posted in 1945 to the Araku valley for doing agricultural propaganda. To start with, seeds, manures and fertilisers were distributed free to the hillmen and they were induced thereby to take to agriculture. This was continued in the subsequent years also and in addition cattle pairs were maintained by the Government and let out for hire for cultivation purposes. Thirty pairs of animals were maintained in 1946 and 193 acres of new lands were thereby brought under cultivation. During 1947, the Araku valley scheme was merged with the Hillmen Uplift Scheme and the free distribution of seeds and manures and agricultural propaganda among the hillmen were continued. Mass selection of seeds from among the local crops was done and the seeds were distributed to the cultivators. White leg-horn poultry were maintained and cockerels were exchanged with the local cocks of the hillmen, to up-grade the hill poultry.

Pilot plots were organized to work out the economics of cultivation units. The Araku Valley Development committee in their proposals contemplated the allocation of one acre of wet land and 5 acres of dry land to every family. This unit of holding was found to be uneconomic when actually worked and would not support a family. The working of these pilot unit holdings suggested that the area of the unit would have to be doubled. Twelve-acre pilot farms formed the unit for cultivation during 1949–50.

(vii) *Subsidiary food crops.*—The Madras State was even in pre-war years a deficit area importing foodgrains, mainly rice, to the tune of 5 lakhs of tons of rice, with a normal production of about 5 million tons of rice. With the cessation of imports of rice from Burma and Indo-China, the prospects were gloomy. Famine commission had recommended the increase in acreage of subsidiary food crops like sweet potato and tapioca as one of the means of getting over the shortage of grain production. It was held that these tuber crops produced 2½ times more calories and energy food than any cultivated cereal from the same extent of land. The cultivation of sweet potato and tapioca was encouraged from the year 1945 onwards. Sweet potato vine cuttings and tapioca setts were distributed free to the cultivators. Assessment was remitted when sweet potato was raised as the only crop in wet or dry lands, water-cess was remitted when sweet potato was raised as the second-crop in wet lands and both assessment and water-cess were remitted when it was raised in irrigable dry lands. Methods of preparing various sweet potato dishes were worked out and recipes were published in the vernacular Grow More Food journals. Dried sweet potato and tapioca slices kept fairly well for over six months. A kind of vermicilli was prepared with sweet potato. As a result of all these and the favourable reception of the tubers in the markets, tapioca and sweet potato cultivation have made appreciable headway. Special mention has to be made of the extension of cultivation of sweet potato in South Kanara and tapioca in Salem district.

Sweet potato is now being cultivated in well over 20,000 acres in South Kanara district, almost throughout the year. The tubers are always available for sale in the market all over the district and to many a poor people it serves as one of two main meals of the day.

The tapioca industry in Salem district is a war baby. People who returned from Malaya during the war established factories for making sago, a semolina substitute and flour from tapioca tubers. There are about 25 factories now handling large quantities of tubers, turning out these products and stimulating the increase of acreage under tapioca in Salem.

(viii) *Plant protection service.*—The crops are affected by a number of insect pests and diseases caused by microscopic organisms. Many of these are controllable by remedial measures taken in time. It has been estimated that the loss caused by pests and diseases may be about 10 per cent in the field and another 10 per cent occurring in the storage of the harvested produce. These losses were heavy no doubt, but their incidence was not felt in normal times and when deficit of food started pressing the country, the need for controlling pests and diseases was considered as important as producing more food, and plant protection service in the country came into being. Fortunately chemicals like DDT, Gamaxene, BHC, Guezarol and a host of others capable of controlling insects effectively were developed during the war years. These had been tested on a large scale for clearing Malaria in the tropical war zones and for delousing the soldiers in Italy under the threat of an epidemic of typhoid. These were later used against crop pests and forms suitable for the various pests were developed. These chemicals are either applied as a dust over the crop with dusting machines or as water or kerosene emulsion spray with special sprayers. These operations are all done by plant protection assistants stationed at the various district headquarters in this State, one for pests and another for diseases. Sprayers, dusters and the various fungicides and pesticides are held in stock at the various taluk Agricultural Depots. The plant protection staff arrange for treating crops affected with pests and diseases. The required chemicals are sold to the cultivators and the plant protection staff assist the ryots in spraying and dusting the chemicals with the equipment stocked in the depot. The Plant Protection Service has become very popular in the State now within a period of about two years and the cultivators have realized the value of taking timely remedial measures. There is a large demand for pesticides and chemicals worth over 4½ lakhs of rupees were used by the cultivators during 1949–50.

A few of the spectacular controls are against the thrips on chillies which bring about the crinkling and reduction in the size of leaves, the ear-head bugs on rice, sorghum and other cereals which appear in large numbers and suck the milky juice of the developing grains and the rats that live in the rice field bunds and take a toll on the ear-heads. The rats are baited with rice flour preparations mixed with zinc phosphide. The rats take the

poisoned mixture and die in large numbers. Zinc phosphide is sold in small packets in the Agricultural depots. The Agricultural Demonstrators, maistris and Plant Protection staff help in tackling pests and diseases and the cultivators can freely draw on their services.

Future developments.—It was postulated in the beginning that agricultural research should aim at elaborating improvements in agricultural practice and simplified methods of transferring them on to the ryot's fields and that they should be within the reach of the ordinary cultivators. Simple agricultural improvements were being advocated to the cultivators for adoption. It was, however, noticed that even where it was proved beyond doubt that the improvements suggested were better than the local methods of cultivation, the ryots would not easily adopt them. The illiterates among the ryots were apathetic and the literate critic took hold of every opportunity to belabour the department. This was very heart-rending and the progress made was slow and halting.

Changes were, however, seen from 1944 onwards and there has been an overwhelming demand for departmental supplies and services. The conditions created by the war, the shortage of food in the country that was pressing heavily on all alike, the rise of prices of almost all commodities, a conspicuous change in the psychology and mental attitude of the people and an allround eagerness to make easy money and big profits got reflected in agriculture also. The general apathy gave place to an eagerness, cultivation methods changed and measures for improvements in cultivation were freely adopted. The Agricultural Demonstrator who had to be going in search of the cultivator has now come to be sought after. The cultivator now wants seeds, fertilisers, pipes, iron, oil engines and pump, tractors and so forth. For most of these, an overwhelming demand has developed.

It can be safely stated that the interest created among the people towards improvements in agriculture will be of an abiding nature. The production of foodgrains is much less than the country's full requirements and this ensures an effective demand for agricultural produce. The price levels of agricultural commodities are high enough to sustain the enthusiasm and interest created towards improved agriculture. People have realized the value of improved seeds, manures and fertilisers. A demand for heavy machinery and tractors has developed, largely as a result of scarcity and high cost of manual and cattle labour. The holdings are small sized and individual cultivators cannot afford to purchase these heavy machinery. But it may be expected that either co-operative or other corporate bodies would come forward for purchasing these machinery and hire them out to the cultivators at reasonable rates. In America, such agencies have developed recently in large numbers and are doing yeoman service. Similar developments may be expected in this State also. A few enterprising people in Guntur have already a fleet of tractors and are hiring them out. The future may, on the whole, be said to be rosy and full of promise.

CHAPTER 32.

AGRICULTURAL STATISTICS AND INFORMATION.

Geographical features of Madras State—Areas available, cultivated, cultivable and waste—Census reports—Soils—Irrigation systems—Agricultural meteorology—Rainfall and other data—Crop weather studies—Population in Madras State—Crop production, extent of cultivation, crop outturn, prices of agricultural commodities, weights and measures, area under improved strains—Agricultural legislation—The Madras Commercial Crops Act, 1933—The Sugarcane Act, 1934—The Cotton Ginning and Pressing Factories Act, The Cotton Transport Act, The Madras Cotton Control Act, The Agricultural and other Produce (Grading and Marketing) Act, 1937—The Destructive Insects and Pests Act, 1914—The Madras Diseases and Pests Act, 1919—The Fruit Products Control Order—The Madras Sugar Factories Control Act, 1949.

Geographical features of Madras.—Madras is situated in the southernmost part of India. It is bounded on the east by the Bay of Bengal, on the west by the Arabian Sea and on the north by a zig-zag land line separating it from the adjoining Orissa State and the table-land of Madhya Pradesh in the extreme north-east. The Krishna and the Tungabhadra rivers mark it out from Hyderabad. On the extreme north-west its territory is delimited by the North Kanara district of Bombay. The States of Mysore, Coorg, Cochin and Travancore lie adjacent to the boundaries of Madras. The coast-line on the east facing the Bay of Bengal extends from Ichapuram in Visakhapatnam district in the north down to Cape Comorin near Tirunelveli district in the south, covering a distance of nearly 1,200 miles. The West-coast begins with the outskirts of North Kanara in Bombay and extends along South Kanara, Malabar and Cochin, comprising a distance of nearly 450 miles.

The State has two large mountain systems, the Western and the Eastern Ghats. The Western Ghats run almost parallel to the sea-coast southward at distances ranging from ten to fifty miles from the sea without any break except for the 16-mile wide Palghat gap. The average height is about 4,000 feet but in some places the height reaches nearly 8,000 feet, the highest peak being Dodabetta of the Ootacamund hills which is 8,640 feet high. The Eastern Ghats start from the frontiers of Orissa and stretch across the State in a south-westerly direction and touch the Western Ghats at the Nilgiris mountains. The height of the Eastern Ghats ranges from 3,000 to 5,000 feet. These two mountain ranges have outliers scattered all over the State, known by different names in different regions like Shevroys in Salem district, the Pachamalais and Kollimalais in Salem and Tiruchirappalli districts, Javadi hills in North Arcot district, Anamalais in Coimbatore district, Palni hills in Madurai district and Nallamalais in Kurnool district.

The State thus consists of a narrow strip of land between the Western Ghats and the Arabian Sea, a broader strip between Eastern Ghats and the Bay of Bengal and an elevated tract lying midway between the two.

The principal rivers are the Godavari, the Krishna and the Cauvery which have their origin in the remote recess of the Western Ghats in Bombay State. There are also rivers of secondary importance like the Pennar, Palar, Pennayar, Vaigai and Tambraparani. All the rivers, big and small, flow generally from west to east. The tributaries of the Godavari river are the Wardha, Indravathi and Sabari, while those of Krishna river are Bhima, Tungabhadra and Musi. The chief tributaries of the Cauvery are Hemavathi Lakshmanathirtha, Kabbini and Bhavani. Neither for navigation nor for irrigation are the rivers useful in the upper reaches, but in the lower reaches on the plains, they lend themselves to be dammed up and regulated for irrigation purposes in the deltaic regions.

Physical features.—The whole land surface is broken by hills and dales, lakes and waterfalls, plains and highlands. This variegated physical structure is the creation of the formations of the Eastern and Western Ghats. The physical features differ cardinally from region to region. The fertile deltas of Cauvery, Godavari and Krishna stand in striking contrast to the bleak and infertile soil of Anantapur and Bellary. The salt marshes in the south of Tanjore, the dry uplands of the Central districts, the dense verdure of the tropical jungles of Wynaad and the dry, the treeless and vast expenses of the black cotton belts bring to vivid light the considerable variation in physical features of the State.

The total area of the State was 125,839 square miles of which 4,587 square miles were under Agency tracts in the districts of Visakhapatnam and East Godavari and 22,894 square miles under zamindaris.

The land area of the State in 1948–49 comprised of the following :—

	MILLION ACRES.
1 Area under cultivation	31
2 Forests	13¼
3 Not available for cultivation	14
4 Other uncultivated land, excluding current fallows.	12
5 Current fallows	10
Total ..	80¼

Appendix I shows the classification of the lands according to the above categories in each of the years 1920–21 to 1948–49 and Appendix II shows the distribution in 1948–49 in each of the districts.

The State comprises 25 districts of which Madras City is one. The present district boundaries have been the result of historical, political or administrative factors. The number of districts has been increased from 20 during 1902–03 to 24 in 1948–49 excluding Madras City. The Guntur district was formed in 1904–05, Ramnad district in 1909–10, Chittoor district in 1910–11. The Godavari district was bifurcated into two, viz., East Godavari and West Godavari, during 1924–25. The Visakhapatnam district was bifurcated in 1950 as North Visakhapatnam and South Visakhapatnam.

The number and names of taluks comprising each district can be found in Appendix III.

The number of villages in Madras was 39,231, the largest number being in Ramanathapuram (3,654), North Visakhapatnam (2,780), Chittoor (2,603), Tanjore (2,669), Chingleput (2,319), South Arcot (2,376) and North Arcot (2,095). While the 220 taluks in the districts are each provided with an agricultural demonstrator, in some taluks there are additional agricultural demonstrators.

The authors of the census reports followed the traditional system of classification of the State as detailed below. These terms of classification, though generally used, are not at present adopted in the Season and Crop Reports :—

Region.	*Districts comprising the region.*
1 The Circars	Vishakapatnam. East Godavari. West Godavari. Krishna. Guntur.
2 The Carnatic	Nellore. Chingleput. South Arcot.
3 The Ceded Districts	Kurnool. Bellary. Anantapur. Cuddapah.
4 The Central Districts	North Arcot. Chittoor. Salem. Coimbatore.
5 The Southern Districts	Tanjore. Tiruchirappalli. Madurai. Ramanathapuram. Tirunelveli.
6 The West Coast Districts	Malabar. South Kanara.
7 The Mountain District	The Nilgiris.

Soils.—The soils of the State are for the most part loamy, gravelly or sandy derived from the disintegration of the local rocks. These alternate with the alluvium of the great river deltas, which

varies in character according to the nature of the soils and drainage basins of the rivers concerned. There are also wide stretches of what is commonly called "black-cotton soil" which is, when pure, an extremely retentive clay of great stiffness. The largest fields of the latter are found in Guntur, in the Kunda valley of Kurnool and Cuddapah, in the eastern part of Bellary and the adjoining taluks of Kurnool and Anantapur, in the southern parts of Coimbatore and the Palni taluk of Madurai and in the southern parts of Madurai and the neighbouring taluks of Ramanathapuram. The laterite soils occur mostly along West Coast.

The soils of the State can be broadly divided into five main types and the areas where they are extensively found are noted below :—

Type of soil.	*Region where extensively found.*
1 The alluvial soils ..	Deltaic tracts of Krishna, Godavari and Cauvery and portions of South Arcot and Tirunelveli.
2 The black cotton soils ..	Kurnool, Guntur, Krishna, Bellary, Ramanathapuram, Tiruchirappalli and Tanjore.
3 The red soils	West Coast, North Arcot, Chittoor, Salem and Coimbatore.
4 The laterite soils	Regions which are subjected to alternate heavy precipitation of over 100 inches of rainfall per annum and a dry hot period such as the region along the West Coast and the Nilgiris district.
5 The saline soils	In arid as well as humid regions, for example, in portions of South Arcot, Guntur and Tiruchirappalli districts where drainage conditions are poor.

Irrigation system.—Irrigation is most highly developed in the Godavari, Kistna and Cauvery deltas and in parts of Cumbum and Tambraparni valleys. Rain water and to some extent river water are also stored in innumerable tanks and lakes. The chief sources of irrigation are Government canals in all deltaic districts, private channels in Visakhapatnam and East Godavari districts, tanks in Chingleput, Ramanathapuram, North Arcot, Chittoor, Tirunelveli, South Arcot and Nellore; wells in Coimbatore, Salem, South Arcot, North Arcot, Tiruchirappalli, Madurai and Tirunelveli and other sources such as spring channels in Visakhapatnam and Chingleput. Canals, tanks and wells are also of the same importance in Madurai and Tirunelveli (Appendix IV). Though there are no recognized systems of irrigation in the West Coast, there is some irrigation from channels and streams. During 1948–49, out of nearly 10 million acres under irrigation, Government canals accounted for 45 per cent, tanks for 30 per cent, wells for 20 per cent and other sources for 5 per cent.

Irrigation works are divided into three classes, (i) productive, (ii) protective and (iii) minor works. Productive works are those that produce sufficient revenue to cover working expenses and interest charges on the capital cost. Protective works are constructed primarily with a view to the protection of precarious

tracts and to guard against the necessity for periodical expenditure for the relief of the population in times of famine. Minor works include generally those which are not classified as productive or protective. The majority of them are indigenous works which Government have taken over, improved and maintained. They include inundation canals, many small tanks, storage reservoirs, minor tanks and petty irrigation works.

The construction of the Stanley Reservoir at Mettur across the Cauvery was completed in the decennium ending fasli 1340 (1930–31). It is expected to supply water to an extent of 301,000 acres chiefly in Tanjore, Mannargudi and Pattukkottai taluks of Tanjore district. Next in importance come the Lower Anicut on the Coleroon under which about 94,000 acres are usually irrigated and the Periyar system which in 1940–41 irrigated 132,600 acres of first crop and 51,000 acres of second crop. The Kurnool-Cuddapah Canal has a very large protective capacity but hitherto the largest area irrigated under it in any year has been 88,919 acres in 1904–05 and the average area irrigated in ordinary years recently has been about 65,000 acres. Cauvery, Periyar and Tambraparni irrigation systems have storage reservoirs which enable timely flow and agricultural operations and planting in the southern districts of the State while Godavari, Krishna and Pennar irrigation systems in the northern districts of the State have no storage reservoirs. Appendix V shows the average area of crop raised in ordinary seasons under the various classes of irrigation works in each district. It will be seen that while the great river systems irrigate the largest area, the importance of the smaller works and wells is very great. The three river systems, viz., Godavari, Krishna and Cauvery are of primary importance, irrigating as they do more than 2½ millions of acres of land. The area of first and second crops irrigated was 10 lakhs in Godavari system, nine lakhs in Krishna and 12 lakhs in the Cauvery.

AGRICULTURAL METEOROLOGY.

Madras lies entirely within the tropics. The surrounding seas on three sides often cause cyclone, storms and floods due to torrential rainfall especially when they strike the coast-land and frequently pass inward, with disastrous results. Failure of crops resulting from insufficient or untimely rainfall is almost a general feature in certain tracts like the Ceded districts. These two extremes generally account for famines and distress.

(i) *Famines.*—The following statement shows the famines in the State from 1900 onwards caused by total failure of crops over two or more seasons in succession :—

1900	..	Ceded districts and portions of Nellore and Kistna.
1901	..	Cuddapah, Anantapur, Chingleput and North Arcot.
1905	..	Part of Chingleput district.
1919	..	Part of Nandigama taluk of the Kistna district.
1921–22	..	Portions of Bellary, Anantapur and Kurnool districts.
1924	..	Portions of Bellary and Anantapur districts.

1926	..	Dharapuram taluk of Coimbatore district.
1931–32	..	Portions of Bellary district.
1934–35	..	Portions of Bellary and Anantapur districts.
1937–38	..	Bellary, Anantapur and Kurnool.
1939	..	Parts of Coimbatore district and five taluks of Chingleput district.
1942–43	..	Parts of Bellary, Anantapur and Kurnool.

(ii) *Cyclones.*—Cyclones and storms arising from depressions in the Bay of Bengal and striking the tract on the East Coast are observed to be almost an annual feature in the State. Abnormally heavy rains bring down floods causing breaches in rivers and tanks. Crops are submerged or washed away resulting in considerable loss. The degree of intensity of the cyclone and the storm varied in the different years and in the severest forms of the deluge there were much loss of property and even of life and livestock. The following statement shows the cyclones and storms which occurred in Madras State from 1905–06 to 1947–48 :—

Year.	*Month.*	*Region affected.*
1905–06	.. September	.. Visakhapatnam district—unusually disastrous type.
1911–12	.. Do.	.. Srikakulam division of Visakhapatnam district.
1913–14	.. May ..	. Visakhapatnam district.
1916–17	.. November	.. Tracts bordering on the trijunction of Chingleput, South Arcot and North Arcot.
1922–23	.. Do.	.. Godavari and Krishna.
1923–24	.. Do.	.. Visakhapatnam—A severe type.
1924–25	.. July ..	.. The whole of the region covered by the Cauvery and Coleroon—unprecedented floods and heaviest damage of crops by silting up of thousands of acres of wet lands.
1925–26	.. November	.. From Badagara to Cannanoore on the West Coast.
1927–28	.. Do.	.. Nellore—Most devastating storm.
1928–29	.. October	.. From Masulipatnam in Krishna district up to Kakinada.
1929–30	.. May ..	.. South of Nagapattinam and parts of Central districts.
1930–31	.. October	.. South of the Madras Coast—unprecedented floods in Cauvery and damages in Tanjore and Tiruchrappalli.
	.. November	.. North Madras Coast.
	Do.	.. South Madras Coast—crops and property damaged in a number of places in southern districts.
1933–34	.. December	.. South Arcot and Chingleput.
1936–37	.. October	.. From Nellore to East Godavari—severe intensity—Bapatla in Guntur district was the worst affected.
1938–39	.. November	.. Krishna, East and West Godavari.
1939–40	.. Do.	.. South Arcot, Tanjore and Tiruchirappalli.
	May ..	.. Nellore.
1940–41	.. Do. ..	.. Ponnani taluk of Malabar.
	November	.. Tanjore and South Arcot—specially Nagapattinam, Tiruturaipundi and Shiyali.

Year.	*Month.*	*Region affected.*
1941–42	May	South of Kozhikode in Malabar district.
1943–44	October	Chingleput district and Madras City.
	Do.	Nellore.
1944–45	Do.	East and West Godavari, Krishna and Guntur —very heavy rains and floods.
1945–46	Do.	The cyclonic storm associated with a tidal wave five to seven feet high inundated the coastal belt between Kakinada and Masulipatnam causing very great loss especially to crops.
1946–47	November	Guntur.
	December	Nellore and Tiruchirappalli—due to continued heavy rains, agricultural operation was at a standstill for one week in the two districts during December.

(iii) *Rainfall.*—The annual rainfall was highest in the West Coast (120 to 150 inches) and next in the hills (55 to 65 inches). The lowest rainfall was in the Ceded districts (20 to 30 inches) and Central districts (25 to 40 inches). Other areas received 30 to 45 inches. For purposes of convenience, the year is divided into the following seasons:—

1	The south-west monsoon	June to September.
2	The north-east monsoon	October to December.
3	The dry weather	January to March.
4	The hot weather	April and May.

The south-west monsoon.—This monsoon sets generally in the middle of June and extends up to September-October. These rains received during this period are of great value to the State, as the Krishna, the Godavari and the Cauvery and Tambraparni depend on them for the supply of water. From July to September the rainfall is generally heavy except in the southernmost parts of the State and parts of Coimbatore. The rainfall is more than nine inches in most of the districts. Over a greater portion it exceeds 13 inches, but the rainfall is low in the extreme south during this period. The greater portion of the annual rainfall of the West Coast is received at this period, about 90 inches in Malabar and 120 inches in South Kanara. The Circars area of the East Coast gets fairly heavy rainfall during the south-west monsoon ranging from 20 to 25 inches. The central elevated plateau of the Ceded districts receives 8 to 10 inches only.

The north-east monsoon.—The rains during the north-east monsoon commence in the early part of October in the coast north of Madras, and continue after December in the coast south of Madras. In the extreme south, the monsoon becomes established in November and continues partly until February. The monsoon rains are helpful in filling up the rainfed tanks in the districts of Chingleput, Nellore. North Arcot, Madurai, etc. Rainfall from 15 to 20 inches annually is received in these districts at this period. The central plateau is once again a dry zone during the north-east monsoon also and gets very little rainfall, 5 to 10 inches. Malabar and South Kanara receive 10 to 15 inches.

The dry weather.—The rains of the dry weather (January to March) are usually too scanty and unreliable to have much effect on agricultural practice. But they are useful to pastures and cold weather crops such as gingelly.

The hot weather.—The rains received during the hot weather period (April and May) are popularly known as "Mango-showers." The rains often take the form of thunder-showers. In Coimbatore, Tirunelveli and Madurai districts the hot weather rains are distributed between April and May while in other districts the rains are received mostly in May and are generally of the nature of pre-monsoon showers. In Malabar and South Kanara about 10 to 12 inches are received in this period and are therefore useful for the first crop. In the Nilgiris about 12 inches are received and useful for the first crop of potatoes.

(iv) *Climatological description of the State.*—According to climate and rainfall, the Madras State can be grouped under four categories, viz., (1) the West Coast strip and adjacent mountain regions with a rainfall ranging from 71 inches to 150 inches, mostly received during the south-west monsoon, (ii) the North-east coast which enjoys both the monsoons and has a rainfall of between 40 inches to 70 inches, (iii) the South-east coast which has rains during the retreating monsoon averaging 30 inches to 50 inches, (iv) the Central plateau which is generally dry and arid with a rainfall of about 20 inches to 25 inches where dry farming is practised. Climate has played its part in the types of soil in respect of weathering, but mean temperatures are uniformly high with little local variation. The hottest zone is the central plateau with a long dry summer and short cool winter resembling the continental type of climate. The coastal areas have moderate temperatures and a moist climate all through the year, typical of tropical conditions.

The Northern Circars receive a rainfall up to 50 inches with an average of 30 to 40 inches distributed over 65—70 days in the south-west monsoon period. The average maximum temperature ranges between 86° F. and 99° F. and the average minimum temperature between 64° F. and 79° F.

The Carnatic districts in normal seasons have a well-distributed rainfall ranging from 35 inches to 40 inches distributed over 70 to 75 days. The climate is equable. The mean temperature is between 75° F. and 88° F. There is hardly a difference between maximum and minimum temperature.

The Deccan is the most arid part of the State. The annual rainfall varies from 20 inches to 30 inches distributed over 50 to 60 days. The temperature may rise easily to 110° F. in summer and fall to 55° F. in winter. This tract is subject to famines.

The central districts are arid regions where the rainfall varies from 20 inches to 30 inches distributed over 60 days. The average maximum temperature is 96° F. to 100° F. and the average minimum being 64° F. to 75° F.

The southern districts are benefited more by the north-east monsoon than by the south-west monsoon. The average maximum temperature ranges from 83° F. to 104° F. and the average minimum from 68° F. to 79° F.

The West Coast is a region of excessive rainfall with 100 inches to 150 inches distributed over 135 to 140 days mostly in south-east monsoon period and possesses a warm moist climate quite different from the other parts of the State. The average maximum temperature varies from 83° F. to 98° F. while the average minimum temperature is between 68° F. to 82° F.

The Nilgiris district has an elevation of 3,000 to 8,000 feet. The rainfall is about 60 inches in 150 days. The average maximum temperature varies from 60° F. to 75° F. while the average minimum temperature is between 45° F. to 55° F.

(v) *Agricultural seasons.*—It is the distribution of the monsoon rainfall that is responsible for agricultural seasons. Timely and well-distributed rains have a favourable effect on the agricultural operation in general. Based on rainfall, there exist some well-defined seasons of cropping in Madras as shown below :—

Name of the season.	*Period.*	*Districts.*
1 Punasa ..	.. April-May to July-August ..	In the Circars districts.
2 Peddapanta ..	August to December	Do.
3 Pyru	November to March	Do.
4 Mungari or early ..	June to October	In Ceded districts.
5 Hingari or late ..	September to March	Do.
6 Samba	August to January	In the southern parts of the State.
7 Kar	June to October	Do.
8 Navarai	December to April	Do.

It is significant that agriculture in Madras is controlled more by natural weather conditions than by any other factor and that agricultural practices have to adjust themselves very much to the vagaries of weather conditions and monsoonic rains and availability of water in river systems and tanks and wells.

In Appendix VI is given the monthly average rainfall in each district.

(vi) *Agricultural Meteorology Section.*—A separate wing of the Agricultural department is working under the Agricultural Chemist, for conducting research on weather and the crops from 1948. Analysis of existing data reveal that over a series of years about 50 per cent of variability of crops can be attributed to weather conditions. While the effect of rainfall on the irrigated rice crop of Godavari and Tanjore deltas was not found significant, a positive correlation was found in Malabar. In rainfed sorghum at Coimbatore, the date of sowing was found very important in influencing the yield, while a dry fair weather of about a month before the harvest was advantageous. The section is issuing periodical weather reports, and collaborating with the Agricultural

Meteorology department at Poona, in compiling weather data, and conducting experiments on the effect of weather on the yield of different crops, on crop rotation and on pests and diseases.

POPULATION IN MADRAS STATE.

(i) *Number.*—The total population of the Madras State excluding Indian States according to the census of 1941 was 49,341,810 or, excluding also that of the Agency tracts in the northern districts, 48,848,504. Fifty years ago, in 1891, the population of the State was only 34 millions. During this half a century, it has increased by 46·3 per cent.

Year of census.	*Population.*
1871	31,281,177
1881	30,868,504
1891	33,732,664
1901	36,258,955
1911	39,129,111
1921	40,205,243
1931	44,205,243
1941	49,341,810

Out of the total population of over 49 millions in the State, 41 millions live in villages. Only eight millions inhabit the towns. The distribution of urban and rural population from 1891 to 1941 is given below.

Census year.	*Urban population.*	*Rural population.*	*Percentage of urban to total population.*
1891	3,406,105	32,224,335	9·6
1901	4,275,178	33,923,984	11·2
1911	4,892,626	36,512,778	11·8
1921	5,278,705	37,040,280	12·5
1931	6,337,256	40,402,851	13.6
1941	7,864,883	41,476,927	14·9

The proportion of rural population to the total population was as high as 84 per cent. Though this is lower than all-India figure which is 87 per cent, compared with other rural countries this is very high. The proportion of rural population to total population is 46 per cent in Canada, 49 per cent in Northern Ireland and 51 per cent in France. It will be seen that the proportion of urban population has been steadily increasing.

(ii) *Occupation.*—The following table gives the distribution of the population according to occupation during 1921 and 1931. Figures relating to 1941 census are not available.

	1921.	*1931.*
Pasture and agriculture	14,986,910	12,570,439
Fishing and hunting	113,972	166,567
Mining	4,208	13,177

	1921.	1931.
Industry	2,215,497	2,288,206
Transport	208,543	294,585
Trade	1,204,109	1,035,043
Public administration and Arts ..	406,690	522,752
Miscellaneous	1,346,744	9,304,702

The census figures of 1931 showed that in Madras, out of every 1,000 persons, 445 persons had no work and were dependent for their living on those who worked. The remaining 555 people consisted wholly of workers or working dependents. Out of these 555 people, 270 were dependent on agriculture, 77 on industry, trade and transport, 11 on public administration and 197 on miscellaneous occupations. Within agriculture, out of every 1,000 persons engaged, 429 were agricultural labourers, 390 cultivating owners, 120 cultivating tenants, 34 non-cultivating owners and 16 non-cultivating tenants. The predominance of agricultural labourers is at once apparent. The birth rate every year in the State was over 1½ millions, while the death rate was over a million.

S. Y. Krishnaswami in his book " Rural problems in Madras " observed that the Madras State had during the past 50 years a birth rate which, on the whole, tended to increase, while the death rate remained fairly constant. All schemes to be formulated in the State which have anything to do with population, will have to take into account the probability of the continued rapid growth of population in the immediate future.

Appendix VII shows the population of Madras by districts in the five censuses held from 1891 to 1941. Except during the epidemic of influenza, the population has been increasing at a geometric rate of about 1 per cent every year.

The percentage of population in the census of 1931, according to occupations, is given in Appendix VIII. The population was highest in Malabar (3·9 millions), Visakhapatnam (3·8 millions), Salem (2·9 millions), Coimbatore (2·8 millions) and Tanjore (2·6 millions). The population was lowest in Nilgiris (two lakhs) and Ceded districts (one million each).

CROP PRODUCTION.

Extent of cultivation.—The distribution of cultivated area among the different crops indicates the structure of agricultural production. Appendix XI shows the areas under important food and non-food crops in the State over the period from 1920–21 to 1948–49, while Appendix XII gives the percentage of area under the main crops from 1922–23 to 1948–49.

Out of the total area under crops of about 37 million acres, food crops occupied normally about 28 million acres and non-food

crops eight to nine million acres. The area under food and non-food crops comprised the following :—

	MILLION ACRES.
Food crops—	
Paddy	10·8
Millets	12·8
Pulses	3·0
Condiments and spices	0·6
Sugar	0·2
Fruits and vegetables including root crops	0·7
Non-food crops	
Groundnut	3·7
Other oil seeds including coconuts	1·7
Cotton	2·0
Tobacco	0 3
Other fibres—Indigo, drug and narcotics, fodder crops, etc.	1·1

Food crops occupied 75 to 80 per cent of the cultivated area and non-food crops 20 to 25 per cent. Among food crops, rice occupied the first place as the chief staple food, and millets were the next in importance. The area under rice and the different millets and pulses showed the following percentages to the total cultivated area :—

	PER CENT.
Rice	27 to 30
Cholam	11 to 14
Cumbu	6 to 7
Ragi	4 to 5
Pulses other than horsegram	3 to 4

The percentage areas in respect of non-food crops were—

	PER CENT.
Groundnut	11 to 12
Gingelly	1 to 2
Castor	½ to 1
Coconut	1 to 2
Cotton	3 to 7
Tobacco	½ to 1

Appendix X shows the percentage of area under each of the food and non-food crops in the State from 1922–23 to 1947–48. The percentage area under groundnut has increased from five in 1922–23 to over ten in recent years; while cereals had declined from 69 per cent to 64 per cent, and food crops on the whole from 80 to 76 per cent.

The area under each of the important crops rice, sorghum, bajra, etc., in different districts is given in Appendix XI to XLVI.

Crop outturn.—The actual production of principal crops in each year from 1921–22 to 1947–48 is furnished in Appendix XLVII.

In Appendix XLVIII is given the yield per acre (average for the State) estimated to be attained in each of the years from 1921–22 to 1948–49 as compared to the normal yield for the important crops.

The figures in these two Appendices (XLVII and XLVIII) are those taken from the Season and Crop Reports published by the Board of Revenue.

The method adopted in recording the outturn of crops in the Season and Crop Reports is described below.

The yield of crop is the product of three factors, namely, (*a*) the acreage under the crop, (*b*) the normal yield per acre and (*c*) the seasonal factor. As regards the first factor, the figures for cultivated acreage are obtained from village accountants to begin with and consolidated by the Tahsildar for the whole taluk and by the Collector for the district and sent to the Economic Adviser, after making due allowance for under-reporting and non-reporting. No allowance is made for excessive damage of lands by floods, droughts, or other abnormal causes unless the land once sown is ploughed over and resown; but the damage caused by floods, etc., is accounted for in the estimate of yield. When more than one crop is raised on the same land, account is taken of the acreage under each crop separately.

The second factor, i.e., normal yield per acre, has been fixed for each crop for each district in the light of (i) crop-cutting experiments, (ii) the yields on the Government farms, (iii) local knowledge of Agricultural Officers and (iv) the results of the comparison of the figures of yield with the figures of nett export and the estimate of consumption. The normal yield was first fixed for each crop for each district during 1919, and has been revised recently for cotton, sugarcane and tobacco.

The third factor known as "Seasonal factor" indicates the effect of the season on the yield of crops. It is worked out in the following manner. An average anna figure for each district is, in the first instance, worked out in the central office by taking a weighted average of the anna estimates reported for the several taluks. This average anna estimate is then converted into a percentage on the assumption that the normal yield for which the seasonal factor is taken as 100 is represented by 12 annas. The condition factor so arrived at is then modified by the application of a correcting factor to allow for the pessimism of the reporting authorities, taking the average seasonal factor for the previous ten years as 100. The corrected seasonal factor is then examined in the light of (i) the reports of District Agricultural Officers regarding the condition of the crop and (ii) the statistics of actual rainfall for each district as compared with the normal, and revised where

necessary to accord with the state of the season. In the Season and Crop Reports up to 1904–05, the seasonal factor was indicated by recording the anna estimate, 12 annas representing an average crop. From 1905–06 onwards, the average outturn was indicated in parts of 100, 100 denoting a normal crop. From 1921-22, the seasonal factor for assessing the average yield was denoted by percentage figures.

Prices of Agricultural Commodities.—The trend of prices of the important food and non-food crops is furnished in Appendices XLIX to XLVII. While the prices in respect of rice, cholam, cumbu and ragi are available for the period from 1921–22 to 1948–49, the prices of commercial crops, jaggery, groundnut, gingelly and castor are given for the years from 1929–30 to 1947–48. The figures in the appendices were taken from the Season and Crop Reports and represent the harvest prices based on the average of the retail prices reported by Collectors as prevailing in two or three of the principal markets in each district.

Weights and measures.—One of the draw-backs in the marketing of agricultural produce is the multiplicity of weights and measures adopted by the trade. There is great diversity and much confusion with regard to weights and measures used in the various districts. For instance, the "maund" for all India means a weight of 3,200 tolas, but it is only 900 tolas in Visakhapatnam, 1,000 tolas in Coimbatore and 1,120 tolas in South Kanara. Similarly, a "Kuncham", a measure commonly used in Northern districts varies from 96 fluid ounces to 128 ounces within the same district of Visakhapatnam and is 220 fluid ounces in Krishna and 560 fluid ounces in Nellore. There is similar diversity in the "Marakkal" which varies from 96 fluid ounces in North Arcot to 312·3 fluid ounces in Chingleput. The "seer" is 44 ounces in Krishna, 40 ounces in Nellore and 41·7 ounces in Bellary and South Kanara. The most common weight freely used in Madras by the railways and which is the basis for price quotations in *Fort St. George Gazette* is the Imperial Maund of 82·2857 lb.

To avoid this confusion in the existing weights and measures and to standardise the same for uniform adoption throughout the States, the Government of India enacted in 1939, a legislation fixing the All-India standards of weight. It was left to State Governments to fix local weights in terms of multiples and sub-multiples of the All-India weights. The Madras Government passed the Standards of Weights and Measures Act in 1948, but rules have not been framed under the Act and the Act is, therefore, not yet enforced in the Madras State. However, the standards of weights and measures for Madras prescribed under the Act are furnished in Appendix LVIII for information.

The Madras Standards of weight prescribed were the "palam" (8 tolas), Madras seer (24 tolas), viss (120 tolas), Madras maund (960 tolas) and candy (19,200 tolas). Standards have also been

prescribed in the Act of 1948 for jeweller's weights, measures of length and area (Vide Appendix LVIII).

Area under improved strains.—During the past four decades, the Agricultural department in Madras has evolved a number of improved strains for important crops, having many desirable characters as compared to local varieties as increased yield, better quality, earliness, resistance to pests and diseases, etc. A list of such strains evolved is given in Appendix LIX for rice, sorghum, bajra, ragi, setaria, groundnut, sesamum, castor, coconuts and cotton. In each crop, strains have been evolved for each major tract or variety, for irrigated and rainfed crops, for different sowing seasons and with different duration periods to suit local needs. The important characters of each strain and the districts in which they have been distributed is given in the Statements for each crop in Table LIX.

The position regarding the distribution of strains during 1949 is summarised below :—

Crop.	*Number of strains.*	*Area covered 000 acres.*	*Area under crop (1948–49) 000 acres.*	*Percentage of area covered by improved strains.*
1 Rice	79	..	10,430	About 45 per cent.
2 Sorghum	33	936	4,777	20
3 Bajra	9	158	2,359	7
4 Ragi	14	343	1,609	21
5 Setaria	7	313	1,704	19
*6 Groundnuts ..	4	400	3,699	11
7 Sesamum ..	3	80	613	13
8 Castor	4	4	230	2
9 Cotton	10	629	1,632	39
10 Sugarcane ..	..	..	176	About 95 per cent.

The area covered by improved strains was highest in sugarcane (95 per cent), and next in rice and cotton, where very large acreages are now under improved strains.

AGRICULTURAL LEGISLATION.

(1) *The Madras Commercial Crops Market Act*, 1933, *with later amendments.*—The object of the Madras Commercial Crops Market Act, 1933 (Madras Act XX of 1933), is to provide for the better regulation of the buying and selling of commercial crops in the Madras State and for that purpose to establish markets for the same. Under this Act, "Commercial Crops" mean cotton, groundnut or tobacco, and include any other crop or product notified by the State Government as a commercial crop for the purpose of this Act.

The Government may by notification declare their intention of exercising control over the purchase and sale of any commercial crop or crops in any specified area which may comprise the whole

or parts of a district or more than one district. A market committee will be established for that area. No person shall thereafter within such notified area set up, establish or use or continue any place for the purchase or sale of a notified commercial crop except under and in accordance with the conditions of a licence granted by the Collector. The grower of a commercial crop or a co-operative society is exempted from taking out such a licence, but the word grower shall not include a dealer or broker in that crop.

The Market Committee shall consist of not more than twelve members elected from (1) the growers, (2) traders, as may be fixed by the Government, who may also appoint to sub-committee any member or members not exceeding the number to be elected. The District Agricultural Officer shall be ex-officio member of the Committee. The Committee can collect fees from purchasers of commercial crop or crops bought and sold in the notified area. The funds of the Committee can be used for the maintenance and improvement of the market, acquisition of sites, construction of buildings, supply of market information, provision of standard weights and measures and schemes for improvement of the commercial crop. The committee shall elect a Chairman and Vice-Chairman and enact by-laws to regulate market practices, including the conduct of proceedings, fixation of tare commission, trade allowances, standard weights, etc., and the checking of scales and weights. The by-laws of the Committee should be approved by the Director of Agriculture.

No trade allowance is permitted in the notified area and all samples shall be paid for. The Government shall make rules consistent with the Act, among other things, for election of members, issue of licences and registrations, inspection of weights and scales. standardization of grades and contracts, settlement of disputes and expenditure of money.

The Accounts of the Committee shall be audited by the Examiner of Local Fund Accounts. The Chairman, Vice-Chairman and every officer or servant of the Market Committee shall be deemed public servants within the meaning of section 21 of the Indian Penal Code.

The Act has been applied to cotton and groundnuts in the Bellary and Anantapur districts, to cotton in Nandyal and Tiruppur, to tobacco in the Guntur district, to tobacco and groundnut in Vijayavada taluk of the Krishna district, to groundnut in the South Arcot district, to tobacco and coconuts in East Godavari and to coconuts and arecanuts in Malabar and South Kanara.

The Collector shall be the election authority for the notified area, and shall perform the functions of Chairman of the Committee when both the offices of Chairman and Vice-Chairman are vacant. He can remove the Chairman or Vice-Chairman from

office, if such a removal is recommended by a resolution of the Committee, supported by not less than two-thirds of the members of the Committee.

It shall be the duty of the District Agricultural Officer to regularly attend meetings of the Committee, to watch the progress of work and to report to the Director of Agriculture on any matter which requires special attention in the efficient discharge of the Committee's work.

(2) *The Sugarcane Act (XV) of* 1934.—The object of the Act is to regulate the price of sugarcane intended for use in factories in order to assure to the grower a fair price. The Act extends to the whole of India.

The State Government may according to section 3 of the Act declare any specified area as a controlled area for purpose of this Act and fix a minimum price or prices for purchase by factories in that area; and may also prohibit the purchase of such cane otherwise than from a grower or from a person licensed by the Government as a purchasing agent. A notice of not less than thirty days shall be given by publication in the Gazette, before issue of such orders.

Any person purchasing cane for a factory in the controlled area at a price less than the minimum price fixed, shall be punishable with fine which may extend to two thousand rupees.

The Government shall make rules among other things for the conduct of enquiries, setting up of Advisory Committees, issue of licences to purchasing agents, organization of societies of growers and maintenance of books and registers, under the Act.

The Government of India may by previous publication make rules for exempting certain factories from the provisions of this Act.

With the coming into existence of the Madras Sugar Factories Act of 1949, the Sugarcane Act (Central) of 1934, in so far as it applies to the State of Madras stands repealed.

(3) *The Cotton Ginning and Pressing Factories Act (XII) of* 1925.—The object of the Act is for better regulation of cotton ginning and cotton pressing factories in the whole of India.

According to section 3, the owner of every cotton ginning factory shall maintain in the prescribed form a ginning register of all cotton ginned in the factory with the quantities, dates and names of persons for whom ginning is done. A pressing factory shall similarly maintain a register in the prescribed form of the quantities of cotton pressed daily and the names of owners of the cotton. Such registers should be produced for inspection by any

officer appointed by the Government. The owner of every pressing factory shall cause every bale pressed in his factory to be marked in the prescribed manner.

The owner of every cotton pressing factory shall submit to the Director of Agriculture weekly returns showing the number of bales of cotton of different varieties pressed during the preceding week and up to that week for the season, and a weekly statement giving such totals for the State will be published by the Director of Agriculture. The season for the purposes of the Act shall commence on the 1st day of February every year.

The Act provides (section 6) that no scale or weights shall be used in any cotton ginning or pressing factory other than those prescribed as standards by the Central Government for the district concerned. Ginning houses shall be provided with separate entrances and exits for bringing in of unginned cotton and taking out of ginned cotton and the factories shall be constructed in accordance with plans and specifications approved by the prescribed authority, who for the Madras State is the Commissioner of Labour.

The following officers are empowered to inspect factories and examine standard weights and scales in cotton ginning and pressing factories in the State of Madras, namely :—

(1) The Commissioner of Labour, Madras.

(2) Inspector of Factories, and

(3) The Director of Agriculture, Madras, Deputy Directors of Agriculture and District Agricultural Officers.

(4) *The Cotton Transport Act* (*Act III of* 1923).—The object of the Act is to provide for the restriction and control of the transport of cotton in certain zones so that the quality and reputation of cotton grown in certain protected areas in India may be maintained.

The State Government (section 3) may by notification in the Gazette prohibit the import of cotton or any specified kind of cotton into any prescribed area in Madras by rail, road, river or sea, save under and in accordance with a licence issued by the Director of Agriculture.

Any railway servant or stationmaster may refuse to book or deliver any cotton the carriage of which to a notified station is prohibited, except under a licence, as aforesaid which shall be attached to the invoice or way bill. Any person contravening these provisions shall be liable to a fine not exceeding one thousand rupees for the first offence and upon subsequent conviction to imprisonment which may extend to three months or to fine which may extend to five thousand rupees or to both.

Under the Act, cotton means every kind of unmanufactured cotton, that is to say, ginned and unginned cotton, cotton waste and cotton seed.

The protected areas for cotton kapas, ginned cotton and cotton waste are—

(1) *Northerns and Westerns Area*, consisting of the districts of Bellary, Anantapur, Cuddapah, and Kurnool (except Markapur and Cumbum taluks).

(2) *The Cambodia area* comprising the districts of Chingleput, South Arcot, Chittoor, North Arcot, Salem, Coimbatore, Tiruchirappalli, Tanjore and that portion of the Mathurai-Ramanathapuram districts outside the Tirunelveli area defined below.

(3) *Tirunelveli area.*—Tirunelveli district and portion of the Mathurai-Ramanathapuram districts lying to the west and south of the Kothagudi river, the east and south of the Vaigai river and portions to the north of the Vaigai river bounded by the Periyar channel up to Melur and thence by the Melur-Sivaganga-Manamadura road.

The taking in of cotton kapas, ginned cotton or cotton waste to any station situated in any of the above protected areas from any station outside is prohibited, except under a licence. Transport of cotton seed into the Northerns and Westerns areas is permitted without restriction throughout the year. Transport of cotton seed into the Tirunelveli area is permitted only at the discretion of the Director of Agriculture from the 1st of December of each year to the 31st of May of the following year.

The Director of Agriculture may require the inspection of any consignment of cotton by an officer of the Agricultural department before the grant of a licence for the import of the consignment. The rates for such inspection shall be as follows :—

(1) Ginned cotton or cotton waste.—Rupee one per bale of 400 lb. or part thereof.

(2) Unginned cotton.—Rupees two per bale of 800 lb. or part thereof.

(3) Cotton seed.—Annas eight for every 1,000 lb. or part thereof.

The levy of fees for the inspection of ginned or unginned cotton, cotton waste and cotton seed shall, however, be subject to a minimum of Rs. 100 in respect of each inspection irrespective of the number of varieties of cotton inspected. The Officer will not be deputed for inspection outside the limits of the State.

(5) *The Madras Cotton Control Act* (*VII of* 1932).—The object of the Act is to provide for the prohibition of the cultivation of *Pulichai* cotton and the mixing of such cotton with other cotton and also the prohibition or restriction of the trade in such cotton, pure or mixed.

As defined in the Act, the word "cotton" means cotton plant, ginned and unginned cotton, cotton waste and cotton seed.

The Government may by notification in any area prohibit the cultivation, mixing or trade in *Pulichai* cotton. Officers authorized by Government are empowered between the hours of 6 a.m. to 6 p.m. to enter upon any land where *Pulichai* is suspected to be grown or any place where it is suspected to be mixed and seize such cotton.

The Officer shall take a sample of the cotton seed, separate it into three equal parts, seal them in the presence of the owner and two witnesses and send one sample for examination to the Cotton Specialist and another to the nearest cotton breeding station, and a report in prescribed form sent to the Director of Agriculture and the District Magistrate. The remainder of the cotton may be left with the owner after taking an undertaking from him in writing that it shall be produced before any Court when required or the Officer may make other arrangements for its safe custody. If in the opinion of the Cotton Specialist the sample contains *Pulichai* cotton, the Officer may after getting the sanction of the Director of Agriculture, file a complaint to the District Magistrate for prosecution of the offender. If the sample is free from *Pulichai*, the fact shall be intimated to the Director of Agriculture and proceedings dropped.

The Act will be enforced in the districts of Mathurai, Ramanathapuram, Tirunelveli and Coimbatore. Deputy Directors of Agriculture, District Agricultural Officers, and Special Agricultural Demonstrators in the area are empowered to exercise the powers of inspection and seizure under the Act.

(6) *The Agricultural and other Produce (Grading and Marking) Act*, 1937.—This Act was passed by the Government of India to provide for the grading of agricultural and other produce under defined standards and the marking of produce so graded. Agricultural produce includes all produce of agriculture or horticulture and all articles of food and drink wholly or partly manufactured from such produce and fleece and skins of animals.

The Central Government may authorize a person or body of persons to mark with a grade specification any article included in the schedule which includes the following :—

(1) Fruits.
(2) Vegetables.
(3) Eggs.
(4) Dairy produce.
(5) Tobacco.
(6) Coffee.
(7) Hides and skins.
(8) Fruit products.
(9) Ata (wheat flour).
(10) Oil-seeds.
(11) Vegetable oils (including hydrogenated oils and vegetable fat).
(12) Cotton.
(13) Rice.
(14) Lac.
(15) Wheat.
(16) Sunn-hemp (fibre).
(17) Sugarcane gur (jaggery).
(18) Myrobalams.

The person authorized to grade, called "Authorized packer" is granted a certificate permitting him to grade a specified commodity for a prescribed period. Labels of different colours or marks

are provided for each grade and it is the duty of the authorized packer to see that the quality graded conforms to the standard fixed by the Government of India under the rules for that commodity. Any person who uses a grade specification mark not being authorized to do so, is punishable with fine which may extend to five hundred rupees. If any authorized packer is found not to comply with the definition of quality prescribed for that article, the grade designation mark will be removed while the certificate of authorization will be cancelled.

In Madras the following commodities are being graded, viz. :—

(1) Sathgudi oranges.
(2) Eggs (hen).
(3) Tobacco.
(4) Sunn-hemp (fibre).

The grading of rice, mangoes, jaggery and potatoes were also done. Under the Sea Customs Act, tobacco or sunn-hemp (fibre) cannot be exported outside India, except under a grade designation mark under the Agricultural Produce Grading and Marking Act.

The State Marketing Officer and Assistant Marketing Officers are empowered to enter and inspect premises of authorized packers, check the quality, take samples and examine the records and make reports to the Agricultural Marketing Adviser to the Government of India, Delhi. Any person who desires to take up grading under this Act, should apply to the Agricultural Marketing Adviser to the Government of India through the State Marketing Officer in the prescribed form. Persons who desire to grade ghee should undertake to equip themselves with a suitable laboratory, and also provide for the salary of qualified chemists employed by the Marketing Adviser.

Any charges incurred by the Government of India in supplying labels, instruments or equipments will be recovered by a charge on the graded produce fixed by that Government.

Details of the working of this Act are given in the chapter on Agricultural Marketing.

(7) *The Destructive Insects and Pests Act*, 1914.—This Act was enacted by the Government of India to prevent the introduction into India of any insect, fungus or other pest which is or may be destructive to crops. When Government notify the prohibition or regulation of any article or class of article under this Act, Customs officers are empowered to deal with the article by confiscation or destroyal as though it has been prohibited under the Sea Customs Act. The Act was later amended in 1938 to enforce the prohibition or restriction of such articles from one State of India to another. When the import is permitted under certain conditions, the person concerned should produce a certificate from the prescribed authority that such conditions have been fulfilled and the article is free from insect pests and diseases.

In the case of living plants imported into India a certificate should be issued from prescribed authority in the country of origin. No plants other than fruits and vegetables intended for consumption, potatoes, sugarcane and unmanufactured tobacco shall be imported into India by sea except after fumigation with hydrocyanic acid and at a prescribed port.

(8) *The Madras Agricultural Pests and Diseases Act*, 1919.—This Act provides for measures being taken to prevent the spread of insect pests, plant diseases and noxious weeds injurious to health or to crops, plants, trees or water-supply or obstructive to waterways within the State of Madras.

If the Government consider that any pest, disease or weed in any local area is dangerous for the purposes of the Act, a notification will be published in the local Gazette, (*a*) declaring the pest as offensive, (*b*) prohibiting or restricting its removal or prescribing preventive or remedial measures and (*c*) defining the area and period for which such notification will be in force. On the issue of such notification every occupier within the notified area shall be bound to carry out the remedial and preventive measures prescribed. If the measures include the removal or destruction of the plant, any occupier who fails to remove or destroy the plant before the specified date shall be deemed to have committed an offence under this Act, and the Inspecting Officer may carry out such removal or destruction under his supervision. Compensation is payable to destruction of trees or plants under certain circumstances but no compensation is payable for the destruction of cotton plants removed to prevent or eradicate disease.

Prosecutions under this Act require the previous sanction of the Collector and no prosecution can be commenced after six months from the date of the alleged offence.

(9) *The Fruit Products Order*.—Fruit products were graded under the Agricultural Produce Grading and Marking Act till 1946, when the work was transferred under the Essential Supplies Powers Act to the Fruit Adviser to the Government of India and recently to the State Government. An advisory committee consisting of the Bio-chemist, Fruit Products Laboratory, Kodur as Chairman and one member representing consumers and another of the licensees has been formed. No person shall carry on the business of a manufacturer of fruit products except under a licence granted by the licensing officer of the Madras Government, and a fee will be charged at Rs. 40 for the first four thousand rupees and thereafter at Rs. 5 for every five hundred rupees on the value of the manufacture. Every manufacturer shall manufacture fruit products in conformity with the sanitary requirements and the appropriate standard of quality prescribed in the schedule. The sealed packets should be sealed and marked according to rules prescribed and return of stocks should be furnished at the end of each term, and accounts maintained in the proper form. No person

shall sell or expose for sale or despatch or deliver to any agent or broker any fruit product of any of the types specified in the schedule, unless it conforms to the standard of quality prescribed. The provisions of the order do not apply to imported beverages or rural manufactures in small quantities. Any beverage not containing at least 25 per cent of the fruit juice in its composition shall be described as a fruit syrup only, and not fruit juice, squash, cordial or crush. The syrups should not contain less than 10 per cent of the fruit juice. Grade standards have been drawn up in the schedule for fruit juices, cordials and syrups, barley waters, synthetic beverages and syrups, canned and bottled fruits and vegetables, jams, jellys and marmalades, canned and crystallised fruits, preserves, fruit chutneys, vinegar, pickles, dried fruits and vegetables and tomato juice, puree and ketchup.

Any contravention of this order is punishable with forfeiture of the material together with sentence. The State Governments shall sanction prosecutions after consulting the Advisory Committee.

(10) *The Madras Sugar Factories Control Act*, 1949.—This Act is meant to provide for the licensing of sugar factories and regulate the prices and supplies of sugarcane used in such factories and other incidental matters.

The Director of Agriculture designated Sugarcane Commissioner will be Chairman of the Advisory Committee constituted for the purpose, consisting of manufacturers, growers and consumers. No sugarcane can be crushed in a factory except under a licence granted by the Government, valid for ten years and the conditions prescribed regarding quantities crushed and the manner in which sugar will be graded. The Sugarcane Commissioner may reserve any area for that factory and growers in that area may offer cane to the factory who shall enter into an agreement in the prescribed form to purchase all such cane offered subject to a minimum fixed by the Cane Commissioner, for each grower and the maximum consumption of each factory. The occupiers of each factory should maintain registers in proper form showing the names of growers and the quantities of cane offered. Inspectors working under the Cane Commissioner shall be appointed for each factory area to work the provisions of the Act.

No cane shall be sold in any reserved area to any person other than the occupier of the factory and no occupier shall refuse to purchase cane under contract except with the permission of the Inspector. Export or import of cane in the reserved area is prohibited. The Government may, at any time, before the crushing season notify the price to be paid for the cane or the method of calculating such price for different varieties and also permit payment of such instalments as may be specified in the notification.

Crushing of sugarcane without a licence in a factory or against the conditions of the licence is punishable with a fine extending to Rs. 5,000 for each day of the offence. If the occupier refuses to purchase cane in contravention of the Act, or pays less than the price fixed or makes deductions from it, he is liable to be punished with an imprisonment up to six months or with a fine up to Rs. 2,000 or both; and the same punishment can be given to import or export of cane against the provisions of the Act.

A cess of six annas per ton of sugarcane brought into the area for consumption, use or sale is levied.

Rules have been framed for the constitution of the Committee, correct weighments and the methods of determining the percentage of recovery of cane.

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111	Do.	Do. V	Proc. Ind. Acad. Sci., Vol. XXVIII, pp. 56–70.	1948
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113	Do.	Do. VII	Proc. Ind. Acad. Sci., Vol. XXXII, pp. 67–79.	1950
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115	Do.	Do. IX	Do. Vol. XXXII, pp. 205–214.	1950
116	Do.	Scopella ascotila on Oldenlandia spp.	Proc. Ind. Acad. Sci., Vol. XXVI, No. 2, pp. 64–68.	1948
117	Do.	Scopellopsis dalbergiae Gen. Nov. sp. Nov. ..	Proc. Ind. Acad. Sci., Vol. XXVI, No. 2, pp. 60–63.	1947
118	Do.	Exobasidium in South India	Proc. Ind. Acad. Sci., Vol. XXIX, pp. 5–12.	1949
119	Do.	Banded sclerotial diseases of Maranta arundinaceae.	Ind. Phy., Vol. I, No. 2, pp. 129–136 ..	1948
120	Do.	Chaconia tectonae	Ind. Phy., Vol. II, No. 1, pp. 17–19 ..	1949
121	Do.	Ergot on Bamboo	Cur. Sci., Vol. XVIII, pp. 344–345 ..	1949
122	T. S. Ramakrishnan and G. Rangaswami.	Urymyces acori	Cur. Sci., Vol. XVII, pp. 240–241 ..	1948
123	T. S. Ramakrishnan and I. L. Narasimhalu. ..	A new host—Castor for *Oidiopsis taurica*	Current Science, Vol. X, pp. 211–212 ..	1941

124	T. S. Ramakrishnan and K. V. Srinivasan.	Two new rust fungi	Cur. Sci., Vol. XIX, pp. 216–217	1950
125	Do.	Two grass smuts	Current Science, Vol XIX, p. 216–217	1950
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127	T. S. Ramakrishnan and G. Siddalingareddy.	Artificial infection of sorghum with long smut	Cur. Sci., Vol. XVIII, p. 418	1949
128	C. S. Krishnaswami	Estimation of disease resistance in sugarcane mosaic.	Proc. Ind. Acad. Sci., Vol. III, pp. 481–490.	1936
129	Do.	Virus diseases of plants	Proc. Assn. Ecn. Biologists, C.B.E., Vol. I, p. 21.	1931
130	Do.	Betelvine wilt caused by *Phytophthora* sp.	Mad. Agrl. Jourl., Vol. XX, p. 455	1932
131	Do.	Sugarcane Mosaic—Loss due to disease	Mad. Agrl. Jourl., Vol. XX, p. 456	1932
132	Do.	Leaf curl—a transmissible disease of Papaya	Cur. Sci., Vol. VIII, p. 316	1939
133	Do.	Virus disease of plants	Mad. Agrl. Jourl., Vol. XXVI, p. 389	1938
134	K. M. Thomas and C. S. Krishnaswami.	The little leaf of Brinjal—a transmissible disease.	Proc. Ind. Acad. Sci., Vol. X, pp. 201–212.	1939
135	M. S. Balakrishnan	Phytophthora palmivora on Cymphomandra betacea and Carica papaya.	Cur. Sci., Vol. XVI, pp. 146–147	1947
136	Do.	Seedling blight of Hibiscus esculentus caused by Phytophthora palmivora.	Proc. Ind. Acad. Sci., Vol. XXVI, pp. 142–146.	1947
137	Do.	South Indian Phycomycetes I—A fruit rot of Hibiscus esculentus by *Pythium indicum* sp. nov.	Proc. Ind. Acad. Sci., Vol. XXVII, pp. 161–173.	1948
138	Do.	South Indian Phycomycetes II—Some little known species of Pythium occuring in South India.	Proc. Ind. Acad. Sci., Vol. XXVIII, pp. 27–34.	1948
139	M.S. Balakrishnan and C.S. Krishnamurthy.	Seedling blight of Carthamus tinctorius	Cur. Sci., Vol. XVI, No. 9, pp. 291–292.	1947
140	A. R. Srinivasan	Some new hosts of Striga	Cur. Sci., Vol. XVI, No. 10, pp. 320–321.	1947
141	C. S. Krishnamurthy and G. Rangaswami.	A new rust on Jasminium ritchii	Cur. Sci., Vol. XVI, No. 1, pp. 31–32.	1947
142	N. R. Adyantayya	Sphacelia Cenchrus ciliaris	Cur. Sci., Vol. XV, pp. 286–287	1946
143	C. K. Soumini	Investigation on Cereal rusts III *Puccinia purpurea.*	Ind. Phy., Vol. II, pp. 35–38	1949
144	K. Ramakrishnan	Investigation on Cereal rusts II *Uromyces setariae italicae.*	Ind. Phy., Vol. II, No. 1, pp. 31–34	1949
145	H. Sunanda Kamath	Life history of Puccinia ruelliæ on Ruellia prostrata.	Proc. Ind. Acad. Sci., Vol. XXVI, No. 1, pp. 1–6.	1947

GLOSSARY.

Common name. (1)	*Botanical name.* (2)	*Vernacular name.* (3)
Abyssinian Teft grass ..	*Eragrostis Abyssinica* ..	....
Acid lime	*Citrus aurantifolia* ..	Tam : Elumichai. Tel : Nimma. Kan : Nimbae. Mal : Cherunaranga.
Aeroplane Wood tree ..	*Ochroma legopus*	....
Akasa Thamarai	*Pistia stratiotes*	....
Avacado pear or Alligator pear	*Persea americana*	Tam : Berikkai. Tel : Berrikai. Kan : Berikai.
Agave..	*Agave sisalana*	Tam : Kathalai. Tel : Kithanara.
	Limanthemum cristatum ..	Tel : Anthara Thamara.
Apple	*Malus indica*	....
Apricot	*Prunus armeniaca* ..	....
Arecanut	*Areca catachu*	Tam : Pakku or Kamugu. Tel : Vakka. Kan : Adike. Mal : Adaka. Hind : Supari.
Arrowroot (East Indian) ..	*Curcuma angistifolia* ..	....
(West Indian) ..	*Maranta arundiacea.*	
Agathi	*Sesbania grandiflora* ..	Tam : Kathalai. Tel : Kalabanda. Kan : Kalnaru.
Australian drought resistant grass.	*Panicum antidotale* ..	....
Asafoetida	*Ferula alliacia and Ferula foetida.*	....
Bael	*Aegle marmelos*	....
Banana	*Musa paradisiaca and Musa sapientum.*	Tam : Vazhai. Tel : Arati. Kan : Balâe. Mal : Vazha.
Barley	*Hordeum vulgare*	....
Barnyard millet	*Echinochloa colona fumentacea.*	Tam : Kudiraivali. Tel : Oodalu or Barigalu.
Beet-root	*Beta vulgaris*	Tel : Beetu Dumpa.
Bengalgram	*Cicer arietinum*	Tam : Kadalai. Tel : Sanagalu. Kan : Kadale. Mal : Kadalakka. Hin : Cheenai.
Bengal jute	*Corchoreas olitorius, Corchoreas capsularis.*	Tam : Sanal or Sanappu. Tel : Nara gogu. Kan : Goni Naru. Mal : Chanam.

Common name. (1)	*Botanical name.* (2)	*Vernacular name.* (3)
Bendai	*Hibicus esculentus*	Tam : Vendai. Tel : Benda. Kan : Bendo. Mal : Vanda.
Betel vine	*Piper betle*	Tam : Vethilai. Tel : Thamalapaku. Kan : Vilathale. Mal : Vetila. Hind : Pan.
Berseem	*Trifolium alexandrinum*	....
Blackgram	*Phaseolus mungo*	Tam : Ulundu. Tel : Uddulu. Kan : Uddu. Mal : Uzhunnu. Hind : Udid.
Blue gum	*Eucalyptus globulus*	Tam : Karpurama-ram.
Bombay hemp or Bhimilipatam jute.	*Hibiscus cannabinus*	Tam : Pulichai or Pulimanji. Tel : Gogu. Kan : Pundi Palya.
Bilwa	*Aegle marmelos*	....
Ber	*Zizyphus jujuba*	....
Bontha-oodaragaddi	*Panicum stagninum*	....
Billi kichili	*Citrus* sp.	....
Bilimbi	*Averrhoa bilimbi*	....
Buffalo grass	*Brachiaris mutica stapf*	Tam : Erumaipul. Tel : Enumu gaddi. Kan : Konatha hullu.
Bread fruit	*Artocarpus communis*	Tam : Seemaipela.
Bowstring hemp	*Sanseveria roxburghiana*	....
Bullock's heart	*Anona reticulata*	....
Betel nut	*Areca catechu*	Tam : Pakku. Tel : Vakka. Kan : Adike.
Butter fruit	Same as Avacado pear	....
Cabbage	*Brassica olearacea, Var. bullata.*	Tam : Muttaikose. Kan : Kosu.
Camphor	*Cinnamomum camphora*	Tam : Karpuram or Soodam. Kan : Karpura.
Chicory	*Cichorium intybus*	....
Capegooseberry	*Physalis peruviana*	....
Cardamom	*Elettaria cardamomum*	Tam : Elakkai. Tel : Elakkaya. Kan : Elakki. Mal : Alekka.
Carambola	*Averrhoa carambola*	....
Carrot	*Daucus carota*	....
Casurina	*Casurina equisetifolia*	Tam : Chavukku. Tel : Sarvi. Kan : Sarve.
Castor	*Ricinus communis*	Tam : Amanakku. Tel : Amudalu. Kan : Haralu. Mal : Avanakku. Hind : Arandi.

Common name. (1)	*Botanical name.* (2)	*Vernacular name.* (3)
Cashew tree	*Anacardium occidentale* ..	Tam : Mundiri. Tel : Jeedi-mamidi. Kan : Geru-beeja. Mal : Parangi manga. Hind : kaju,
Cauliflower	*Brassica oleracea Var. botritis.*	....
Chengala gaddi	*Iseilema laxum*	....
Cheeni orange	*Citrus sinensis, osbeck* ..	Tam : Kamala. Tel : Narinja. Kan : Sihi-kithale.
Cherimoyer	*Annona cherimolia* ..	....
Chillies	*Capsicum annum*	Tam : Milakai. Tel : Mirapakayalu. Kan : Menasuinakai. Mal : Mulaku.
Sorghum	*Sorghum vulgare*	Tam : Cholam. Tel : Jonna. Kan : Jola. Mal : Cholam. Hind : Jowar.
Citron..	*Citrus medica*	Tam : Elumichai. Tel : Nimba. Kan : Limbae.
Clusterbeans	*Cyamopsis tetragonoloba, Taub.*	Tam : Kothu avarai. Tel : Goruchikkudu. Mal : Chavalaikai.
Cocoa	*Theobroma cacao*	....
Coca plant	*Erythroxylum coca* ..	....
Common millet	Same as Proso or Hog millet.	....
Curry leaf	*Murraya Koenigii*	....
Clove	*Engenia caryophyllata* ..	....
Coconut	*Cocos nusifera*	Tam : Thengai. Tel : Tenkay or Kobbari. Kan : Tengu. Mal : Nalikeram. Hind : Narial.
Cotton	*Gossypium* spp.	Tam : Paruthi. Tel : Pratthi. Kan : Hatti. Mal : Paruti. Hind : Kapus.
Coffee	*Coffea arabica Coffea robusta.*	....
Coriander	*Coriandrum sativum* ..	Tam : Kothumalli. Tel : Dhainyalu or Kothumeri. Kan : Kothambari.
Country almond	*Terminatia catappa* ..	Tam : Batham. Tel : Badam. Kan : Badami.
Cowpea	*Vigna Unguiculata Linn Vigna catiang.*	Tam : Karamani. Tel : Alsandalu. Kan : Alsandae. Mal : Vellappayuru.
Bajra (Pearl millet or Bulrush millet).	*Pennisetum typhoides, Stapf. and Hubbard.*	Tam : Cumbu. Tel : Sajja. Kan : Sajje.

Common name. (1)	*Botanical name.* (2)	*Vernacular name.* (3)
Custard apple	*Anona reticulata Anona squmosa.*	Tam : Seethapalam. Tel : Sethaphalam. Kan : Seethaphala.
Cinnamon	*Cinnamonum zeylanicum* ..	....
Cochinial insect	*Dactylopius tomentosus* ..	....
Daincha	*Sesbania aculata vr, cannabinus.*	Tam : Thakkaipoondu Tel : Jeelugu.
Date palm	*Phoenix dactylifera* ..	Tam : Echan. Tel : Eetha.
Dewgram	*Phaseolus aconitifolius* ..	Tam : Naripayaru Kallupayaru. Tullikkapayaru. Tel : Mittikelu.
Dharbai pul	*Imperata arundinacea* ..	Tam : Dharbai. Tel : Dharba. Kan : Dharbe.
Durian	*Durio zebithinus*	....
Etwatkala grass	*Melinis minutiflora* ..	....
Elephant grass	*Pennisetum purpureum* ..	Tam : Yanaippul. Tel : Enugu gaddi. Kan : Anetha hullu.
Erukkan (Tam)	*Calatropis*	Tam : Erukkan.
Falsa	*Gowia asiatica*	....
Field-bean	*Dolichos lablab*	Tam : Mochai. Tel : Anumulu. Kan : Avare. Mal : Mochakottai. Hind : Ballar.
Fig	*Ficus carica*	Tam : Athi. Tel : Athi. Kan : Athi.
Gajanimma	*Citrus pennivesiculata, Tanaka.*	....
Ganja plant	*Cannabis sativa*	Tam : Ganja. Tel : Ganja. Kan : Ganja.
Garlic	*Allium sativum*	Tam : Vellaipoondu. Tel : Tellagadda. Kan : Bellulli.
Giant star grass	*Cynadon plectostachyum* ..	....
Ginger	*Zingiber officinale, Rosc.* ..	Tam : Inji. Tel : Allamu. Kan : Alla. Mal : Inji.
Gingelly	*Sesamum indicum Linn* ..	Tam : Ellu. Tel : Nuvvulu. Kan : Yallu. Mal : Ellu. Hind : Til.
Gooseberry (Indian) (Otheite).	*Phylanthus emblica Phylanthus distichus.*	Tam : Nellikkai. Tel : Usirikayi. Kan : Nellikkayi. Mal : Nelli. Hind : Amla.
Grape fruit	*Citrus paradisi*	....
Grape	*Vitis vinifera*	Tam : Drakshai and Kodimunthiri. Tel : Draksha. Kan : Drakshi. Mal : Munthiri.

Common name. (1)	*Botanical name.* (2)	*Vernacular name.* (3)
Greengram	*Phaseolur radiatus*	Tam : Pasi payaru. Tel : Pacha pesalu. Kan : Hesara. Mal : Cherupayaru. Hind : Mung.
Groundnut	*Arachis hypogaea*	Tam : Nilakadalai. Verkadalai. Tel : Versanagalu. Kan : Nelagadale. Mal : Nilakkatala. Hind : Vilayetimung ; Mung-phali.
Guava	*Psidium guajava*	Tam : Koyyah. Tel : Jama. Kan : Sabe.
Guinea grass	*Panicum maximum*	Tam : Guineapul. Tel : Guinea gaddi. Kan : Guinea hullu.
Gurrapu gaddi	*Chloris barbata*	....
Golden crown grass	*Paspalum dilatatum*	....
Gold Mohar	*Delonix regia*	....
Hemp plant	*Cannabis sativa*	....
Henbane	*Hyoscyamus muticus*	....
Hill guava	*Rhodomyrtus tomentosa*	Tam : Malaigova or Koyya. Tel : Konda jami. Kan : Bettatha sebe.
Horsegram	*Dolichos biflorus*	Tam : Kollu. Tel : Ulavalu. Kan : Huruli. Mal : Muthira.
Illuppai	*Bassia* spp.	Tam : Illuppai.
Indian hemp (Ganja)	*Cannabis sativa*	Tam : Ganja. Tel : Ganja or Ganjaya or Bangiaku.
Indigo	*Indigofera anil sumatrana.*	Tam : Nili or Avuri. Tel : Nili. Kan : Nili.
Ipecacuanha	*Cephaelis ipecacuanha*	....
Irungu cholam	*Sorghum dochna*	Tam : Erungu cholam. Tel : Irungu jonna. Kan : Irungu jola.
Italian millet	*Setaria italica*	Tam : Tenai. Tel : Korralu. Kan : Navane. Mal : Tena. Hind : Kangoone.
Indian gooseberry	*Phyllanthus emblica*	....
Jack	*Artocarpus integrifolia*	Tam : Pela. Tel : Panasa. Kan : Halasu. Mal : Plavu.
Jalap	*Ipomoea purga*	....
Jamberi	*Citrus jambhiri*	Tam : Kattu Elumichai.
Jasmine	*Jasminum* spp.	Tam : Malligai. Tel : Malli. Kan : Mallige.

Common name. (1)	*Botanical name.* (2)	*Vernacular name.* (3)
Jujube	*Zizyphus jujuba*	Tam : Elanthai. Tel : Regu. Kan : Bori.
Jute—Bengal jute	*Corchorus olitorius* / *Corchorus capsularis*	Tam : Sannal. Tel : Naragogu.
Jute—Bhimilipatam jute	*Hibiscus cannabinus*	Kan : Pundi. Mal : Chanam.
Kadaipul	*Tragus racemosus*	....
Kapok	*Eriodendron pentandrum*	Tam : Elavan. Tel : Bungu doodi.
Kaki weed	*Alternanthera echinata*	....
Karunganni cotton	*Gossypium arborium var. neglectum Forma India.*	Tam : Karunganni paruthy. Tel : Karunganni-patti. Kan : Karunganni-hathi.
Karumpul	*Panicum colonum*	....
Karu gaddi	*Andropogon pertusus, Willd.*	....
Khatta	*Citrus aurantium Tanaka.*	Tam : Aranju.
Kichili	*Citrus madraspatna*	Tam : Kamala.
Kiluwai (Tam)	*Commephora berri*	Tam : Mulkiluvai.
Kikiya grass	*Pennisetum clandestinum.*	....
Kodo millet	*Paspalum scrobiculatum*	Tam : Varagu. Tel : Arika. Kan : Haraka. Hind : Kodra.
Kollaganjeru	*Ipomoea hispida*	....
Kolakattai grass	*Cenchrus ciliaris, Cenchrus setigerus.*	Tam : Kolakattai pull. Kan : Kolakattai hullu.
Kolinji	*Tephrosia purpurea*	Tam : Kolinji. Tel : Vempali.
Korai	*Cyperus rotundus*	....
Korralu	*See Italian millet*	....
Korali	*Sataria pallidifusca Stapf and Hubbard.*	....
Kudzu vine	*Pueraria thumbergiana, Pueraria phoseoloides, Pueraria hirsuta.*	....
Kundara gaddi	*Ischaenum pilosum*	....
Kumquat	*Fortunella* spp.	....
Lablab	*Dolichos lablab*	Tam : Mochai : Avarai. Tel : Anumulu. Kan : Avare. Mal : Avara.
Ladies finger	*Hibiscus esculantus*	Tam : Vendai. Tel : Bendi. Kan : Bende. Mal : Venda.
Langsat	*Lensium chinensis*	....
Lemon	*Citrus limon*	Tam : Kodi elumichai. Tel : Nimma. Kan : Nimbe. Mal : Naranga.

Common name. (1)	Botanical name. (2)	Vernacular name. (3)
Lentil	*Lens esculenta*	....
Lime	*Citrus aurantifolia* ..	Tam : Elumichai. Tel : Nimma. Kan : Limbe.
Linseed	*Linum utilatissimum* ..	Tam : Alivirai. Tel : Avisi.
Litchi	*Litchi chinensis*	....
Little rice	*Chenopodium quinoa* ..	....
Little millet	*Panicum miliare*	Tam : Samai. Tel : Sama. Kan : Sane. Mal : Sama. Hind : Shanan.
Loquat	*Eriobotrya japonica* ..	....
Lucerne	*Medicago sativa*	Tam : Kuthirai masal. Tel : Gurrapu masala.
Lupin	*Lupinus* spp.	....
Maize	Zea mays	Tam : Makka cholam. Tel : Mokka Jonnalu. Kan : Muskinjola. Mal : Makka cholam. Hind : Butta.
Mango	*Mangifera indica*	Tam : Mamaram and Mambazham. Tel : Mamidipandu. Kan : Mavu. Mal : Manga.
Mangosteen	*Carcinia mangostana* ..	....
Manjan pul	*Cymbopogon coloratus* ..	....
Marotti	*Hydrocarpus wighiana* ..	....
Mulberry	*Morus* spp.	Tam : Musakkottai.
Musk melon	*Cucumis melo*	Tel : Karbuza. Kan : Karbuza hannu.
Mandarin	*Citrus reticulata*	....
Mint	*Mentha virides*	....
Nadam cotton	*Gossypium arboreum typicum.*	Tam : Nadan paruthy. Tel : Nadam pathi. Kan : Nadam hatti.
Manabalu gaddi	*Andropogon foeveolatus Del.*	....
Napier grass	*Pennisetum purpureum Schum.*	Tam : Napier pul. Tel : Napier gaddi. Kan : Napier hullu.
Neem	*Azadirachta indica* ..	Tam : Veppan. Tel : Vepa. Kan : Bevu. Mal : Veppu.
Nendra gaddi	*Sehima nervosum*	....
Niger	*Guizotia abyssinica* ..	Tam : Peyellu. Tel : Veerrinuvvulu. Kan : Huchellu.
Nut grass	*Cyperus rotundus*	....
Nutmeg	*Myristica fragrans* ..	....
Oats	*Avena sativa*	....
Omum (Bishops' weed) ..	*Carum copticum*	Tam : Omum. Tel : Omamu. Kan : Omam.

Common name. (1)	*Botanical name.* (2)	*Vernacular name.* (3)
Onion	*Allium cepa*	Tam: Vengayam. Tel: Ulligadda. Kan: Neerulli. Mal: Ulli.
Orange	*Citrus cinensis*	Tam: Orange. Tel: Narinja. Kan: Kithale.
Oil palm	*Elaeis guineensis*	....
Otheite gooseberry	*Phyllanthus distichus*	....
Paddy	*Oryza sativa*	Tam: Nellu. Tel: Vadlu. Kan: Bhatta. Mal: Nellu. Hin: Dhan.
Papaya	*Carica papaya*	Tam: Pappali. Tel: Boppayi. Kan: Parangi. Mal: Kappalanga.
Palmyrah	*Borassus flabellifer*	Tam: Panai. Tel: Thati. Kan: Tala. Mal: Pana.
Pamparapanas	*Citrus paradisi*	....
Panivaragu	*See Proso or hog millet.*	
Pandibellagaddi	*Andropogon contortus*	....
Passion fruit	*Passiflora edulis and Tacsonia mollisima.*	....
Peach	*Prunus Persica*	....
Pear	*Pyrus communis*	....
Pepper	*Piper nigrum*	Tam: Milagu. Tel: Miriyalu. Kan: Menasu. Mal: Kurumulaku.
Pedda Oobagaddi	*Aristida hystrix Linn*	....
Peas	*Pisum sativum*	Tam: Pattani. Tel: Batani. Kan: Batani.
Persimmon	*Diospyros Kaki*	....
Phalsa	*Grewia asiatica*	....
Pillipesara	*Phaseolus trilobus*	Kan: Sannahesuru.
Pineapple	*Ananas sativus*	Tel: Anasa. Kan: Ananasu. Mal: Kadacha.
Pinnai	*Calophyllum inophyllum*	....
Plantain	*Musa paradisiaca*	Tam: Vazhai.
	Musa sapientum	Tel: Arati. Kan: Bale. Mal: Pazham.
Pummelo	*Citrus grandis*	Tam: Paplimas. Tel: Pampara Panasa.
Pomegranate	*Punica granatum*	Tam: Mathulai. Tel: Danimma. Kan: Dalimbe.
Potato	*Solanum tuberosum*	Tam: Urulaik-kizhangu. Tel: Urulagadda. Kan: Alugadde. Mal: Urulakkizhangu.

Common name. (1)	Botanical name. (2)	Vernacular name. (3)
Poovulu gaddi	*Eragrestis bifaria*	....
Pricklypear	*Opuntia dillenii*	Tam : Sappathikalli.
Plum	*Prunus salicina*	....
Proso or hog millet	*Panicum miliaceum*	Tam : Panivaragu. Tel : Variga. Kan : Baragu. Hin : Barri.
Pungam	*Pungamia glabra*	Tel : Kanuga.
Pummelo	*Citrus grandis*	Tel : Pampara Panasa. Mal : Kambilinaranga.
Pulichai cotton	*Arboreium Var. neglectum forma bengalensis.*	....
Pyrethrum	*Chrysanthemum coccineum.*	....
Peppermint	*Mentha piperata*	....
Ragi (Finger millet)	*Eleusine coracana*	Tam : Kezhvaragu or Ragi. Tel : Ragi or chollu or Thaidalu. Kan : Ragi. Mal : Muthari. Hin : Mandwa Ragi.
Rape	*Brassica* spp.	....
Rambutan	*Nephelinum lappaceum*	....
Ratan cane	*Calamus Rotang*	....
Ramaphal	*Annona reticulata*	....
Redgram	*Cajanus cajan*	Tam : Tuvarai. Tel : Kandulu. Kan : Thogare. Mal : Tuvara.
Rhodes grass	*Chloris guayana*	....
Rice	*Oryza sativa*	Tam : Nellu. Tel : Vadlu. Kan : Bhatta. Mal : Nellu. Hin : Dhan.
Rose apple	*Eugenia jambos*	....
Rubber	*Hevea brasiensis*	....
Ramnus purshiana	*Cascara sagrada*	....
Red oil palm	*Elacis guineenisis*	....
Safflower	*Carthamus tinctorius*	Tam : Kusumbavirai. Tel : Kusumbalu. Kan : Kusuma.
Sajja	Same as cumbu.	
Sago palm	*Arenga saccharifera*	Tam : Eechan.
Sapota	*Achras sapota*	Tam : Sapota. Tel : Sapota. Kan : Sapota.
Samai (Tam.)	*See* Little millet.	....
Samba wheat	*Triticum dicoccum*	Tam : Samba gothumai.
Seethaphal	*Anona squamosa*	Tel : Seethaphala. Kan : Seethaphal.
Senna	*Cassia angustifolia*	Tam ; Surat Nilavirai or Nilavakai. Tel ; Nela anagedu.

Common name. (1)	*Botanical name.* (2)	*Vernacular name.* (3)
Singharas	*Trapa bispinosa*	....
Silver oak	*Grevillea robusta*	Tam: Malaicharrukku Mal: Vellimaram.
Soyabean	*Glycine max*	....
Sour orange	*Citrus aurantium*	Kan: Huli kithale.
Sorghum	*See* Cholam.	
Spear grass	*Heteropogon contortus*	Tam: Kosipullu. Tel: Pandibellam. Kan: Sunkari hullu.
Strawberry	*Fragaria vesca*	....
Strawberry guava	*Psidium cattleianum*	....
Star apple	*Chrysophyllum Cainito*	....
Subterranean clover	*Trifolium subterraneaum*	....
Sudan grass	*Sorghum sudanense*	....
Sugarcane	*Saccharum officinarum*	Tam: Karumbu. Tel: Cheruku. Kan: Kabbu. Mal: Karimbu. Hin: Ganna.
Sunflower	*Helianthus annus*	Tam: Suryakanthi. Tel: Suryakanthi. Kan: Suryakanthi. Mal: Suryakanthi.
Sunnhemp	*Crotalaria Juncea*	Tam: Sanappu. Tel: Janumu.
Sanwa millet	*Panicum crusgalli, var. Frumentaceum.*	Tam: Kudiraivali. Tel: Oodalu.
Soursop	*Annona muricata*	....
Stink grass	*Melinis minutiflora*	....
Sweet orange	*Citrus cinensis*	Tam: Enippu orangi. Tel: Battayi. Mal: Madhura naranga.
Sweet potato	*Ipomaea batatas*	Tam: Sarkaraivalli. Tel: Genasu gadda. Kan: Genasu. Mal: Madhura-kizhangu.
Tapioca	*Manihot utilissima*	Tam: Maravelli. Tel: Karna pendalam. Kan: Maragenasu. Mal: Marakizhangu.
Tangedu	*Cassia auriculata*	Tel: Tangedu. Kan: Tangedi.
Tea	*Camelia thea*	Tam: Theyilai. Mal: Chaya.
Tenai	*See* Italian millet.	..
Teosinte	*Euchlaena mexicana*	..
Thamarai	*Nelumbium speciosum*	Tam: Thamarai. Mal: Thamara.
Thin Napier grass	*Pennisetum polystachyon*	....
Tinnelvelly senna	*Cassia angustifolia*	Tam: Nilavarai.
Tomato	*Lycopersicum esculentum Mill.*	Tam: Thakkali. Tel: Seema vanga. Kan: Takkali or Seema badane.

Common name. (1)	*Botanical name.* (2)	*Vernacular name.* (3)
Tobacco	*Nicotiana Tabacum* and *Nicotiana Rustica.*	Tam : Pogailai. Tel : Pogakau. Kan : Hoge soppu. Mal : Pogaila. Hin : Tamakku.
Tree tomato	*Cyphomandra betacca*	Tam : Mara thakkali.
Turmeric	*Curcuma longa*	Tam : Manjal. Tel : Pasupu. Kan : Arasina.
Turnips	*Brassica campestris*	....
Tung oil tree	*Aleurites fordii*	....
Uppam cotton (Tam.)	*Gossypium herbaceum*	Tam : Uppam paruthi. Tel : Uppam pathi. Kan : Uppam hathi.
Varagu	*See* Kodo millet.	....
Variga	*See* Proso or hog millet.	....
Vasambu	*Acorus calamus*	....
Vempali	*Tephrosia purpurea*	Kan : Kadu neeli.
Velam Pasi	*Ceratophyllum demursum.*	Tam : Velampasi.
Venezuela	*Melinis minutiflora*	....
Vanilla	*Vanilla planifolia*	....
Walnut	*Jugulans regia*	....
Wattle	*Acacia decurrens*	Tam : Malaichorrikku.
Water melon	*Citrullus vulgaris*	Tam : Dharbusini.
Water chestnut	*Trapa bisbinosa*	....
Water Hyacinth	*Eichhorinia speciosa*	Tam : Nerthamarai. Tel : Neeti tamara. Mal : Kulavazhia.
Wheat	*Triticum* spp.	Tam : Godumai.
	„ *vulgare*	Tel : Godumalu. Kan : Godhi. Mal : Godambu.
Wild date	*Phoenix sylvastris*	....
Woodapple	*Peronia elephantum*	Tam : Vialambalam.
Water grass	*Brachiaria mutica*	....
Yentrakayalugaddi	*Ischaemum Rugosum Salisb.*	....
Ziziphus	*Ziziphus Jujuba*	Tam : Elandhai. Tel : Regu. Kan : Bore.

GLOSSARY OF PESTS AND DISEASES OF CROPS.

Common name of pest or disease. (1)	*Scientific name of pest or name of causative agent of disease.* (2)
Pests of rice—	
Swarming caterpillar of rice	*Spodoptera mauritia*, B.
King crow	*Dicrurus macrocarcus.*
Common crow	*Corvus splendens.*
Jungle crow	*Corvus macrorhynchos.*
Cattle egret	*Bubulens ibis.*
Paddy bird	*Ardeolagrayii.*

Common name of pest or disease. (1)	*Scientific name of pest or name of causative agent of disease.* (2)
Pests of rice—*cont.*	
Water hen (white breasted)	*Amaurornis phaenicurus.*
Common mynah	*Acridotheres tritis.*
Rice grass hopper	*Hieroglyphus banian.*
Indian roller	*Coracias benghalensis.*
Brahmini kite	*Haliaster indus.*
Pariah kite	*Milvus migrans.*
Common water snake.	*Tropidonotus piscator.*
Rice bug.	*Leptocorisa acuta.*
Climbing cut worm of rice	*Cirphis albistigma.*
Rice hispa	*Hispa armigera.*
Spotted rice jassid	*Nephotettix bipunctatus.*
Striped bug of rice	*Tetroda histeroides.*
Rice thrips	*Thrips oryzae.*
Lesser grass hopper of rice	*Oxya velox.*
Indian wren warbler	*Prinia inornata.*
Rice stem borer	*Schoenobius incertullus.*
Rice case worm	*Nymphula depunctalis.*
Rice mealy bug	*Ripersia oryzae.*
Rice gall fly	*Pachydiplosis oryzae.*
Mole rat	*Gunomys kok.*
Gerbil or Antelope rat	*Tatera cuvieri.*
Grass rat	*Millardia meltada.*
Pests of sorghum—	
Sorghum ear head bug	*Calocoris angustatus.*
Deccan grass hopper.	*Colemania sphenarioides.*
Millet grass hopper	*Hieroglyphus nigrorepletus.*
Sorghum fly	*Atherigona indica.*
Sorghum stem boror	*Chilo zonellus.*
Sorghum mite.	*Paratetranychus indicus.*
Pests of ragi—	
Ragi pink borer	*Sesamia inferens.*
Ragi white borer	*Saluria inficita.*
Ragi root aphis	*Tetraneura hirsuta.*
Pests of redgram—	
Gram caterpillar	*Holiothis obsoleta.*
Redgram plume moth	*Exelastes atomosa*
Sweet potato sphynx	*Herse convolvuli.*
Pests of vegetables—	
Brinjal beetle	*Epilachna* spp.
Fruit borer	*Leucinodes orbonalis.*
Bud worm	*Phthorimoea blapsigona.*
Bhendai jassid	*Empoasca devastans.*
Chillies thrips	*Scirtothrips dorsalis.*
Garlic and onion thrips	*Heliothrips indicus.* *Thrips tabaci.*
Cabbage borer	*Hellula undalis.*
Diamond back moth	*Plutella maculipennis.*
Mustard saw fly	*Athalia proxima.*
Pumpkin caterpillar	*Margaronia indica.*
Snake gourd semilooper	*Plusia peponis.*
Pumpkin beetle	*Aulacophora foveicollis.* *Aulacophora atripennis.* *Aulacophora stevensi.*
Fruit fly	*Dacus* sp. *chaetodacus* sp.
Lablab bug	*Coptosoma cribraria.*
Podborer caterpillar	*Adisura atkinsoni.*
Plant lice	*Aphis medicagenis.*
Lady bird beetle	*Chilomenes sexmaculata.*
Sweet potato weevil	*Cylas formicarius.*
Potato tuber moth	*Gnorimoschema operculella.*

Common name of pest or disease.	*Scientific name of pest or name of casuative agent of disease.*
(1)	(2)
Pests of mango—	
Mango hopper	*Idiocerus niveosparsus.*
	Idiocerus atkinsoni.
	Idiocerus clypealis.
Mango stem borer beetle	*Batocera rubus.*
Mango shoot webber	*Orthaga exvinacea.*
Red ant	*Oecophylla smaragdina.*
Castor slug	*Parasa lepida.*
Pests of fruit trees—	
Orange borer	*Chelidonium cinctum.*
	Chloridolum alcamene.
Fruit sucking moth	*Ophideres fullonica.*
	Ophideres materna.
Citrus butterfly	*Papilio demoleus.*
Berfruit fly	*Carpomyia vesuviana.*
Sapota leaf webber	*Nephopteryx eugraphalla.*
Grapevine flee beetle	*Scelodonta strigicollis.*
Pomegranate butterfly	*Virachola isocrates.*
Cockchafer beetle	*Melolonthidae.*
Cashew thrips	*Selenothrips rubrocinctus.*
Cashew bug	*Helopeltis antonii.*
Wax scale	*Ceroplastes floridensis.*
Wild silk moth	*Cricula trifenestrata.*
Cashew cerambycids	*Plocaederus ferrugineus.*
	Plocaederus consocius.
Pests of sugarcane—	
Early shoot borer	*Argyria sticticraspis.*
Cane borer	*Diatroea (Proceros) venosata*
Top borer	*Scirpophaga* sp.
Cane leaf hopper	*Pyrilla perpusilla.*
Cane grass hopper	*Hieroglyphus banian.*
Pests of cotton.—	
Spotted boll worms	*Earias insulana.*
	Earias fabia.
Pink boll worm	*Platyedra gossypiella.*
Stem weevil	*Pempherulus affinis.*
Cotton jassid	*Empoasca devastens.*
Cotton aphis	*Aphis gossypii.*
Pests of coconut—	
Black headed caterpillar	*Nephantis serinopa.*
Rhinoceros beetle	*Oryctes rhinoceros.*
Red palm weevil	*Rhynchophorus ferrugineus.*
Indian rat	*Rattus rattus wroughtoni.*
Pests of groundnut—	
Red hairy caterpillar	*Amsacta albistriga.*
Groundnut surulpoochi.	*Stomopteryn nerteria.*
Groundnut aphid	*Aphis laburnii.*
Pests of castor—	
Castor semilooper	*Achoea janata.*
Castor shoot and seed borer	*Dichocrocis punctiferalis.*
Castor mite	*Tetranychus telarius.*
Pests of other crops and beneficial insects—	
Betelvine bug	*Disphinctus politus.*
Agathi weevil	*Alcides bubo.*
Tobacco caterpillar	*Prodenia litura.*
Ragi leaf noctuid	*Laphygma exigua.*
Tobacco root bug	*Stibaropus tabulatus.*
Coffee white borer.	*Xylotrechus quadripes.*
Pollu beetle of pepper	*Longitarsus nigripennis.*
Pepper scale	*Lepidosaphes piperis.*
Cardamom thrips	*Taenothrips cardamomi.*

Common name of pest or disease. (1)	*Scientific name of pest or name of causative agent of disease.* (2)
Pests of other crops and beneficial insects—*cont.*	
Domestic fly	*Musca nebulo.*
Cattle fly	*Stomoxys calcitrans.*
Cottony cushion scale or Fluted scale.	*Icerya purchasi Mask.*
Apple woolly aphis	*Eriosoma lanigera.*
Cochineal insect	*Dactylopius tomentosus.*
Rootgall eelworm	*Heterodera marioni.*
Coffee stem borer	*Xylotrechus quadripes.*
Coffee berry borer	*Stephenoderos hampei.*
Rock bee	*Apis dorsata.*
Indian bee	*Apis indica.*
Wax moth	*Galleria mellonella.*
Black ant	*Camponotus compressus.*
Bee hunter wasp	*Palarus orientalis.*
Mulberry silk worm	*Bombyx mori.*
Eri silk worm	*Attacus ricini.*
Tassar and Muga silk worms ..	*Antheroea paphia.* *Antheroea assama.*
Pests of stored products—	
Rice weevil	*Sitophilus oryzae.*
Rice borer beetle	*Rhizopertha dominica.*
Red grain beetle	*Tribolium castaneum.*
Pulse beetle	*Bruchus* spp.
Rice moth	*Corcyra cephalonica.*
Fig moth	*Ephestia cautella.*
House rat	*Rattus rattus rufescens.*
Cheroot beetle	*Lasioderma serricornii.*
Scolytid beetle	*Coccotrypes dactyliperda.*
Diseases of rice—	
Blast	*Piricularia oryzae.*
Footrot	*Fusarium moniliforma var. magus.*
Stemrot or	*Sclerotium oryzae and*
Sclerotial disease	*Helminthosporium sigmoideum.*
False smut	*Ustilaginoide virens.*
Ooodhubathi disease	*Balansia oryzae.* *Ephelis oryzae.*
Rootrot	*Pythium* sp.
Diseases of sorghum—	
Grain smut	*Sphacelotheca sorghi.*
Loose smut	*Sphacelotheca cruenta.*
Head smut	*Spacelotheca reiliana.*
Long smut	*Tolyposporium ehrenbergii.*
Downy mildew or Leaf shredding disease.	*Sclerospora sorghi.*
Rust	*Puccinia purpurea.*
Anthracnose	*Colletotrichum graminicolum.*
Leaf spot	*Cercospora sorghi.*
Leaf stripe	*Helminthosporium turcicum.*
Bacterial leaf spot	*Bacillus holci.*
Sooty blotch	*Ramulispora sorghi.*
Sugary disease	*Sphacelia sorghi.*
Twisted top	*Fusarium moniliforma.*
Mosaic	*Sacharum virus 1.*
Diseases of ragi—	
Blast	*Piricularia* sp.
Blight	*Helminthosporium nodulosum.*
Footrot	*Sclerotium rolfsii.*

Common name of pest or disease.	*Scientific name of pest or name of causative agent of disease.*
(1)	(2)
Diseases of bajra—	
Rust	*Puccinia penniseti.*
Greenear	*Sclerospora graminicola.*
Smut	*Tolyposporium penicilariae.*
Top rot	*Fusarium moniliforme.*
Diseases of setaria—	
Smut	*Ustilago crameri.*
Rust	*Uromyces setariae.*
Green ear	*Sclerospora graminicola.*
Blast	*Piricularia setariae.*
Diseases of varagu—	
Smut	*Sorosporium paspali.*
Diseases of wheat—	
Black rust	*Puccinia graminis tritici.*
Yellow rust	*Puccinia glamarum.*
Brown rust	*Puccinia triticira.*
Diseases of sugarcane—	
Red rot	*Physalosapora tucumanensis.*
Smut	*Ustilago scitaminea.*
Pineapple disease	*Ceratostomella paradoxa.*
Top rot	*Fusarium moniliforme.* *Gibberella fujikuroi.*
Mosaic	*Sacchrum virus* 1.
Diseases of cotton—	
Root rot	*Rhizoctonia bataticola.* *Macrophomina phaseoli.*
Wilt	*Fusarium vasinfectum.*
Boll rot and seedling blight	*Colletotrichum capsici.*
Areolate mildew	*Mycosphaerella areola.* *Ramularis areola.*
Leaf spot	*Alternaria macrospora.*
Black arm	*Xanthomonas malvacearum.*
Diseases of groundnut—	
Tikka disease or	*Cercospora personata.*
Leaf spot	*Mycosphaerella berkeleyi.*
Root rot	*Macrophomina phaseoli.* *Rhizoctonia bataticola.*
Clump disease	*Arachis virus* 1.
Diseases of redgram—	
Wilt	*Fusarium udum.*
Diseases of horsegram—	
Root rot	*Rhizoctonia bataticola.* *Macrosphomina phaseoli.*
Diseases of coconut—	
Budrot	*Phytophthora palmivora.*
Stem bleeding	*Ceratostomella paradoxa.*
Diseases of areca—	
Mahali or Koleroga	*Phytophthora palmivora.*
Wilt	*Ganoderma lucidum.*
Stem bleeding	*Ceratostomella paradoxa.*
Pepper diseases—	
Pollu or root rot	*Diplodia* sp. *Colletotrichum necator.*
Wilt	*Pythium* sp. *Rhizoctonia solani.*
Stump rot	*Rosellinia bunodes.*

Common name of pest or disease.	*Scientific name of pest or name of causative agent of disease.*
(1)	(2)
Diseases of chillies—	
Fruit rot	*Colletotri capsici.*
Broom rape	*Orabanche cernua.*
Damping off	*Pythium aphanidermatum.*
Black shank	*Phytophthora palmivora.*
Diseases of citrus—	
Water injury	*Diplodia* sp.
	Sporocybe hybrida.
	Haplosporella sp.
Leaf fall and fruit rot	*Phytophthora palmivora.*
Disease of banana—	
Panama disease or Wilt	*Fusarium oxysporum var. cubense.*
Diseases of grapevine—	
Downy mildew	*Plasmopara viticola.*
Powdery mildew	*Uncinula necator.*
Bird's eye disease or Anthracnose ..	*Elsinoe ampelina.*
Diseases of other crops—	
Casuarina wilt	*Trichosporium vesiculosum.*
Rubber leaf fall	*Phytophthora palmivora.*
Rubber powdery mildew	*Odium heveae.*
	Odium renese.
Rubber root disease	*Botryo-diplodia theobromae.*
	Fomes noxius.
	Ustilina zonata.
	Rosellinia sp.
Coffee rust or leaf disease	*Hemileia vastatrix.*
Coffee koleroga or Black rot	*Pellicularia koleroga.*
Coffee brown blight	*Glomerella cingulata.*
	Colletotrichum coffearum.
Tea blister blight	*Exobasidium vexans.*

APPENDICES.

APPENDIX I.

Classification of area under forests, fallows and areas sown, etc.

Year. (1)	Forests. (2)	Not available for cultivation. (3)	Other uncultivated lands excluding current fallows. (4)	Current fallows. (5)	Net area sown. (6)	Total area. (7)	Total area sown with *food crops.* (8)	Total area sown with *nonfood crops.* (9)
	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
1920-21	12,985,852	21,826,988	11,997,206	9,878,419	33,073,385	89,761,850	37,553,068	..
1921-22	13,054,784	21,411,397	12,178,856	10,032,332	33,012,244	89,689,613	31,128,220	6,405,008
1922-23	13,108,085	21,319,143	12,170,371	10,211,233	32,997,115	89,805,947	30,630,572	7,131,899
1923-24	13,157,722	21,402,744	12,076,080	11,121,933	32,293,479	90,351,958	28,951,822	7,472,035
1924-25	13,118,282	21,514,535	12,466,142	10,067,658	33,337,946	90,504,513	29,954,494	7,969,123
1925-26	13,158,792	21,117,185	12,351,551	10,143,823	33,833,765	90,606,116	30,034,010	8,754,486
1926-27	13,073,782	20,149,099	13,217,563	10,873,729	33,263,040	90,577,219	29,353,803	8,013,329
1927-28	13,053,682	20,471,022	13,270,696	10,086,524	33,793,466	90,675,390	29,861,261	8,696,817
1928-29	13,100,701	19,750,284	13,346,050	10,901,373	34,037,941	91,166,349	29,516,113	9,263,081
1929-30	13,103,782	19,348,664	13,839,139	10,201,037	34,372,101	90,864,723	30,458,762	8,800,491
1930-31	13,207,150	20,145,525	13,125,846	10,326,235	34,224,124	91,028,880	30,470,033	8,723,168
1931-32	13,333,664	20,515,113	13,099,483	10,704,152	33,495,798	91,148,210	30,375,149	9,157,993
1932-33	13,640,272	20,063,367	13,138,696	10,115,311	34,186,205	91,143,851	30,385,503	8,778,106
1933-34	13,693,112	19,878,901	13,180,616	10,375,409	33,879,523	91,007,561	29,754,422	7,969,428
1934-35	13,803,814	19,792,886	13,441,825	11,165,710	32,801,620	91,004,071	29,761,120	7,777,390
1935-36	13,090,351	16,924,774	11,493,026	10,243,865	31,829,022	83,591,038	28,396,484	8,232,343
1936-37	12,370,947	15,722,154	10,792,613	9,490,987	31,705,506	80,082,207	27,475,726	9,121,686
1937-38	13,178,241	14,603,510	10,537,675	9,451,438	32,081,679	79,802,543	26,623,219	10,294,717
1938-39	13,191,517	14,497,180	10,862,821	9,860,540	31,383,337	79,795,395	27,039,128	8,921,948
1939-40	13,188,205	14,509,826	10,903,914	9,781,173	31,460,404	79,843,525	27,364,653	8,915,190
1940-41	13,321,985	14,115,628	11,316,264	9,299,255	31,959,310	80,012,442	27,826,422	9,517,302
1941-42	13,425,717	13,980,423	11,278,134	9,762,064	31,683,203	80,059,541	28,046,194	8,373,401
1942-43	13,468,419	14,116,144	11,759,619	9,348,567	31,324,380	80,017,129	28,007,451	8,732,752
1943-44	13,307,631	14,214,677	11,551,511	8,911,146	31,890,989	79,875,954	28,927,570	6,777,041
1944-45	13,459,625	14,217,581	11,433,633	9,289,800	31,533,823	79,934,462	27,968,197	9,081,175
1945-46	13,515,797	14,148,429	11,952,664	9,779,379	30,533,664	79,929,933	26,425,724	8,848,692
1946-47	13,496,668	14,054,088	11,848,904	9,498,791	31,035,475	79,933,806	27,628,356	8,784,612
1947-48	13,515,939	14,116,453	12,187,186	10,037,058	30,077,989	79,984,625	26,409,836	8,222,904
1948-49	13,515,130	14,408,034	11,889,786	10,048,334	30,934,289	80,795,573	27,518,182	8,278,494

APPENDIX II.

Statement showing total area of the districts according to the different classifications (1948–49).

District.	Total area of the district.	Deduct area under: Forests.	Deduct area under: Not available for cultivation.	Deduct area under: Other uncultivated lands excluding current fallows.	Deduct area under: Current fallows.	Deduct area under: Total.	Net area sown.	Area under food crops.	Area under non-food crops.	Total area sown.	Area sown more than once.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
Visakhapatnam	5,198,106	1,329,291	1,131,399	664,574	490,850	3,616,113	1,581,992	1,701,448	398,658	2,100,106	518,114
East Godavari	3,639,741	864,855	977,376	592,708	226,862	2,661,801	977,940	1,098,205	192,008	1,290,213	312,273
West Godavari	1,925,887	116,485	275,316	292,047	344,326	1,028,174	897,713	968,903	161,003	1,129,906	232,193
Krishna	2,221,168	125,550	324,279	349,529	231,325	1,030,683	1,190,485	1,123,517	256,437	1,379,954	189,469
Guntur	3,689,980	468,862	450,702	272,282	356,297	1,548,143	2,141,837	1,828,605	561,142	2,389,747	247,910
Kurnool	5,003,244	1,660,142	304,417	641,220	322,880	2,928,659	2,074,585	1,659,973	474,512	2,134,485	59,900
Bellary	3,674,024	364,460	239,179	467,102	347,411	1,418,152	2,255,872	1,629,482	892,637	2,522,119	266,247
Anantapur	4,311,447	452,794	475,188	835,708	521,090	2,284,780	2,026,667	1,516,558	586,792	2,103,650	76,983
Cuddapah	3,798,169	1,156,865	455,704	852,686	332,136	2,797,391	1,000,778	846,306	230,252	1,076,558	75,780
Nellore	5,087,200	473,222	1,580,109	1,043,662	675,636	3,772,629	1,314,571	1,835,732	133,513	1,469,245	154,674
Chingleput	1,953,079	120,834	590,722	275,020	301,873	1,288,449	664,630	718,537	73,164	791,701	127,071
South Arcot	2,693,024	158,618	650,795	197,567	397,879	1,404,859	1,288,165	1,077,252	503,983	1,581,235	293,070
Chittoor	3,771,906	523,755	1,457,512	621,959	423,782	3,027,008	744,898	609,200	224,909	834,109	89,211
North Arcot	2,974,637	768,182	496,258	349,217	284,974	1,898,631	1,076,006	849,035	446,909	12,95,944	219,938
Salem	4,483,101	1,001,635	890,513	569,252	411,327	2,872,727	1,610,374	1,450,096	379,816	1,829,912	219,538
Coimbatore	4,551,876	1,443,347	389,528	188,406	741,752	2,763,033	1,788,843	1,501,247	582,446	2,083,693	294,850
Tiruchirappalli	3,490,077	168,359	656,256	347,171	783,759	1,955,545	1,534,532	1,393,637	340,253	1,733,890	199,358
Tanjore	2,397,981	24,421	626,873	188,978	191,608	1,031,880	1,366,101	1,560,305	110,114	1,670,419	304,318
Ramanathapuram	3,088,090	51,284	714,472	609,753	717,406	2,092,915	995,175	750,233	309,292	1,059,525	64,350
Madurai	3,115,718	741,448	225,624	726,891	261,711	1,955,674	1,160,044	1,041,645	313,713	1,355,358	195,314
Tirunelveli	2,776,422	308,936	403,469	151,677	857,846	1,721,928	1,054,494	854,602	385,432	1,240,034	185,540
Malabar	3,713,011	359,890	616,439	967,628	245,870	2,289,827	1,523,184	1,240,387	562,740	1,803,127	279,943
South Kanara	2,577,295	517,209	406,655	634,796	448,787	2,007,447	569,848	726,199	93,333	810,532	249,684
The Nilgiris	628,887	314,686	37,746	49,953	130,947	583,332	95,555	36,778	65,436	102,214	6,659
Madras	31,503	..	31,503	..	..	31,503	..	..	..	..	..
Total for the State ..	80,795,573	13,515,130	14,408,034	11,889,786	10,048,334	49,861,284	30,934,289	27,518,182	8,278,494	35,796,676	4,862,387

APPENDIX III.

Statement showing number and names of taluks and number of villages in each district.

District.	Taluks.	Total number of villages excluding tributary and proprietary villages.
(1)	(2)	(3)
North Visakhapatnam	1 Srikakulam *	354
	2 Tekkali	339
	3 Patapatnam *	450
	4 Sompeta	221
	5 Ichapur	51
	6 Palakonda *	353
	7 Parvatipur *	463
	8 Bobbili	242
	9 Chipurupalli	307
	Total ..	2,780
South Visakhapatnam	1 Sarvasiddhi *	144
	2 Golugonda *	172
	3 Gudem	115
	4 Viravilli *	265
	5 Anakapalle *	145
	6 Visakhapatnam	72
	7 Bimilipatam	175
	8 Srungavarapukota	186
	9 Vizianagaram *	212
	10 Salur	217
	Total ..	1,703
	Total for the whole district ..	4,483
	Plains.	
East Godavari	1 Ramachandrapuram *	117
	2 Amalapuram *	106
	3 Razole*	108
	4 Rajahmundry *	84
	5 Peddapuram *	220
	6 Kakinada *	106
	7 Pithapuram	53
	8 Tuni	52
	Total ..	846
	Agency.	
	1 Yellavaram	332
	2 Chodavaram	276
	3 Polavaram	140
	4 Bhadrachalam	328
	5 Nugur	150
	Total ..	1,226
West Godavari	1 Narasapur *	89
	2 Tanuku *	103
	3 Bhimavaram *	90
	4 Tadepalligudem	115
	5 Eluru *	144
	6 Kovvur	117
	7 Chintapudi	110
	Total ..	768
Krishna	1 Bandar	116
	2 Divi	100
	3 Gudivada *	118
	4 Kaikalur *	101
	5 Gannavaram *	129
	6 Vijayavada *	125
	7 Nandigama *	182
	8 Tiruvur	90
	9 Nuzvid	83
	Total ..	1,044

* Taluks provided with additional agricultural demonstrators.

APPENDIX III—*cont.*

***Statement showing number and names of taluks and number of villages in each district*—cont.**

District. (1)	Taluks. (2)	Total number of villages excluding tributary and proprietary villages. (3)
Guntur	1 Ongole *	176
	2 Bapatla *	111
	3 Tenali *	91
	4 Repalle *	60
	5 Guntur *	125
	6 Sattenapalle	125
	7 Narasaraopet	114
	8 Vinukonda	77
	9 Palnad	93
	Total ..	982
Kurnool	1 Pattikonda	73
	2 Dhone	77
	3 Kurnool *	97
	4 Nandikotkur *	92
	5 Nandyal *	78
	6 Koilkuntla	86
	7 Sirvel	87
	8 Cumbum	104
	9 Markapur *	95
	Total ..	784
Bellary	1 Bellary *	107
	2 Siruguppa *	79
	3 Rayadrug	81
	4 Adoni *	165
	5 Alur	94
	6 Hospet *	137
	7 Hadagalli	59
	8 Harpanahalli	101
	9 Kudligi *	113
	Total ..	938
Anantapur	1 Anantapur *	118
	2 Kalyandrug	74
	3 Gooty *	135
	4 Tadpatri	97
	5 Dharmavaram	63
	6 Kadiri *	146
	7 Penukonda	105
	8 Hindupur *	87
	9 Madakasira	61
	Total ..	886
Cuddapah	1 Badvel	148
	2 Proddatur *	87
	3 Siddhout	80
	4 Rajampet *	145
	5 Cuddapah *	113
	6 Jammalamadugu	188
	7 Pulivendla	97
	8 Royachoti	118
	9 Kamalapuram	64
	Total ..	982
Nellore	1 Gudur	117
	2 Rapur	89
	3 Nellore *	124
	4 Kovur *	88
	5 Kavali	80
	6 Atmakur *	116
	7 Udayagiri	131
	8 Kandukur *	187
	9 Kanigiri	210
	10 Sulurpet *	149
	11 Zamindari divisions	426
	Total ..	1,717

* Taluks provided with additional agricultural demonstrators.

APPENDIX III—*cont.*

Statement showing number and names of taluks and number of villages in each district—cont.

District. (1)	Taluks. (2)	Total number of villages excluding tributary and proprietary villages. (3)
Chingleput	1 Madurantakam *	418
	2 Kancheepuram *	340
	3 Chingleput *	315
	4 Saidapet *	197
	5 Sriperumbudur	250
	6 Tiruvallur *	406
	7 Ponneri	398
	Total ..	2,319
South Arcot	1 Tindivanam *	305
	2 Gingee	245
	3 Villupuram *	238
	4 Cuddalore *	242
	5 Tirukkoyilur	358
	6 Kallakurichi	359
	7 Vridhachalam	296
	8 Chidambaram *	343
	Total ..	2,376
Chittoor	1 Chittoor *	380
	2 Chandragiri *	283
	3 Palamaner *	405
	4 Madanapalle *	110
	5 Vayalapad	127
	6 Zamindari tracts, Kalahasti * ..	1,303
	Total ..	2,608
North Arcot	1 Tirupattur	231
	2 Gudiyattam *	187
	3 Vellore *	158
	4 Wallajah	189
	5 Arkonam	143
	6 Cheyyar	222
	7 Wandiwash	207
	8 Polur *	180
	9 Tiruvannamalai *	214
	10 Chengam	184
	11 Arni	180
	Total ..	2,095
Salem	1 Hosur	335
	2 Krishnagiri	164
	3 Dharmapuri	151
	4 Harur	144
	5 Omalur	129
	6 Tiruchengode	167
	7 Salem *	217
	8 Attur *	184
	9 Namakkal *	206
	10 Rasipuram *	82
	11 Yercaud	64
	Total ..	1,793
Coimbatore	1 Kollegal	86
	2 Gobichettipalayam *	157
	3 Bhavani	57
	4 Erode *	178
	5 Dharapuram	85
	6 Udamalpet *	96
	7 Palladam	100
	8 Coimbatore	82
	9 Avanashi *	73
	10 Pollachi	217
	Total ..	1,131

* Taluks provided with additional agricultural demonstrators.

APPENDIX III—*cont.*

Statement showing number and names of taluks and number of villages in each district—cont.

District. (1)	Taluks. (2)	Total number of villages excluding tributary and proprietary villages. (3)
Tiruchirappalli	1 Perambalur	134
	2 Udayarpalayam	235
	3 Musiri *	157
	4 Lalgudi *	131
	5 Tiruchirappalli *	125
	6 Karur	122
	7 Kulittalai *	233
	8 Pudukkottai *	..
	Total ..	1,137
	Tanjore Division.	
Tanjore	1 Tanjore *	210
	2 Papanasam	188
	3 Kumbakonam *	231
	4 Mayuram *	191
	5 Sirkali	102
	6 Nannilam *	254
	Total ..	1,176
	Pattukottai Division.	
	1 Pattukottai *	367
	2 Arantangi *	548
	3 Mannargudi *	201
	4 Tiruturaipundi *	157
	5 Nagapattinam *	220
	Total ..	1,493
	Grand total ..	2,669
Ramanathapuram	1 Srivilliputtur	81
	2 Sattur *	251
	3 Aruppukottai	552
	4 Mudukulattur	703
	5 Ramanathapuram	210
	6 Paramakudi	496
	7 Sivaganga *	361
	8 Tiruppattur *	..
	9 Tiruvadanai *	991
	Total ..	3,645
Madurai	1 Madurai *	260
	2 Melur	110
	3 Tirumangalam *	283
	4 Dindigul *	123
	5 Palni	120
	6 Periyakulam *	90
	7 Nilakottai *	141
	8 Kodaikanal	15
	Total ..	1,142
Tirunelveli	1 Ambasamudram *	112
	2 Koilpatti *	267
	3 Nanguneri	119
	4 Sankaranainarkoil *	118
	5 Tenkasi	99
	6 Tirunelveli *	139
	7 Tiruchendur	85
	8 Anjengo	2
	9 Srivaikuntam	108
	Total ..	1,049

* Taluks provided with additional agricultural demonstrators.

APPENDIX III—*cont.*

Statement showing number and names of taluks and number of villages in each district—cont.

District.	Taluks.	Total number of villages excluding tributary and proprietary villages.
(1)	(2)	(3)
Malabar	1 Chirakkal *	272
	2 Kottayam	227
	3 Kurumbranad	341
	4 Wynaad *	58
	5 Kozhikode	188
	6 Ernad *	94
	7 Walluvanad *	317
	8 Palghat *	138
	9 Ponnani *	121
	Total	1,756
South Kanara	1 Mangalore *	182
	2 Kasaragod *	110
	3 Puttur *	184
	4 Udipi *	115
	5 Coondapoor	104
	6 Karkal	106
	Total	801
The Nilgiris	1 Coonoor *	23
	2 Ootacamund	19
	3 Gudalur	12
	Total	54
	Grand total for Madras State	39,281

* Taluks provided with additional agricultural demonstrators.

APPENDIX IV.

Area irrigated in each District from various sources of irrigation (canals, tanks, etc.) in 1948–49.

District.	Area irrigated from — Government canals.	Private channels.	Tanks.	Wells having independent ayacuts.	Wells supplementing recognized source of irrigation.	Other sources i.e., spring channels, etc.	Total.	Percentage of irrigated area to net area sown.	Percentage of area irrigated by wells having independent ayacuts to to the total area irrigated.	Percentage of irrigated area to net area sown in the previous year.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.			
Visakhapatnam	150,537	141,237	461,620	67,308	17,135	48,899	869,601	76·3	7·7	55·1
East Godavari	523,837	..	75,660	120	182	82,362	681,979	69·5	..	55·0
West Godavari	667,873	..	97,930	13,433	..	9,241	788,477	86·1	1·7	93·6
Krishna	584,496	1,758	42,635	38,719	..	13,607	681,215	56·9	5·7	58·2
Guntur	411,344	13	23,174	11,034	963	7,061	452,626	20·9	2·4	21·0
Kurnool	42,058	..	43,543	19,397	..	3,133	108,131	5·2	18·0	5·9
Bellary	32,486	201	14,173	11,135	44	1,815	59,810	2·7	18·6	2·7
Anantapur	36,784	736	84,910	73,680	5,686	2,162	198,222	9·7	37·2	11·4
Cuddapah	63,920	1,069	54,875	86,578	6,178	26,601	233,043	23·1	37·2	23·1
Nellore	158,727	239	263,446	116,698	53,984	5,558	544,668	41·2	21·4	48·2
Chingleput	6,215	2,090	415,295	29,186	47,439	7,860	460,646	65·1	6·3	66·7
South Arcot	196,905	..	272,951	14,430	76,306	15,069	499,355	37·4	2·2	40·1
Chittoor	20,869	3,687	115,382	98,210	16,108	3,260	241,408	37·3	40·7	33·7
North Arcot	25,541	898	227,366	120,058	42,078	4,842	378,705	35·0	31·7	36·5
Salem	28,752	416	59,230	151,809	12,250	21,826	262,033	16·3	5·8	18·4
Coimbatore	80,811	171	19,956	425,318	7,811	10,581	536,787	30·0	14·5	32·9
Tiruchirappalli	149,709	..	157,720	107,330	1,296	16,620	431,379	27·9	24·9	25·9
Tanjore	1,121,234	1,033	40,181	33,057	2,815	541	1,196,046	86·0	2·8	86·7
Madurai	181,534	1,402	111,920	158,860	4,593	1,171	454,887	39·1	34·9	39·9
Ramanathapuram	768	..	253,603	109,004	2,436	51,772	415,147	41·7	26·8	44·7
Tirunelveli	48,549	1,720	208,959	98,802	732	2,017	360,047	34·0	27·4	33·2
State	4,532,899	156,670	8,044,529	1,784,166	297,836	335,948	9,854,212	32·0	18·1	32·2

NOTE.—There are no sources of irrigation on the West Coast and the Hills. Excluding the West Coast and the Hills, 34·4 per cent was irrigated during the year.

APPENDIX V.

Average area of land, in thousands of acres, irrigated in ordinary seasons.

District. (1)	Name. (2)	Large protective Works. First crop. (3)	Large protective Works. Second crop. (4)	Minor Works. First crop. (5)	Minor Works. Second crop. (6)	Wells. First crop. (7)	Wells. Second crop. (8)
		ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
Visakhapatnam	Nagavalli project and channels	16·7	3·4	18·4	1·1	..	..
	Minor river systems	59·3	8·4	21·5	5·4	0·9	..
	Four river systems	30·6	8·1	26·2	2·8	5·1	..
East Godavari	Godavari delta system	356·9	107·2	58·6	3·5	..	..
	Kattu of the Thandava river in Visakhapatnam district.	0 2	..				
West Godavari	Godavari delta system	424·5	155·3	13·1	0·8	0·4	..
	Krishna delta system	40·1	0·6	6·9	..	..	..
Krishna	Krishna delta system	533·8	2·1	8·4	..	6·5	..
	Godavari delta system	1·4	..				
	Divi Pumping system	83·0	..				
	Muniyeru Project	8·8	..				
	Kollair lake	2 8	..				
Guntur	Krishna delta system	347·7	12·9	19·6	2·8	16·8	..
Kurnool	Kurnool-Cuddapah canal	31·5	4·7	34·5	6·0	19·1	1·7
	Cumbum tank	5·1	3·3				
	Markapur tank	1·3	0·8				
	Other works	1·9	0·3				
Bellary	None	..	..	22·8	4·1	17·0	0·3
Anantapur		..	..	118·0	50·9	57·7	17·2
Cuddapah	Kurnool-Cuddapah canal	33·4	6·8	104·2	42·3	74·6	33·6
Nellore	Pennar anicut system	61·4	6·8	..	..	..	..
	Nellore tank	9·4	1·2	11·3	2·8	1·8	0·1
	Ponnalur tank	0·7	0·3	16·2	3·8	5·7	2·5
	Mopad tank	5 6	0·3	31·4	1·5	5·3	4·3
Chingleput	Palar anicut system	20·0	8·8	252·6	87·9	15·4	6·7
	Other works	26·5	7·4				
South Arcot	Tirukkoyilur anicut system	20·9	4·5	238·1	123·4	84·5	2·5
	Lower Coleroon anicut system	83·1	0·7				
	Other Works	81·1	17·2				
North Arcot	Palar anicut System	49·9	25·2	178·9	102·2	77·1	31·8
	Poiney anicut system	18·0	7·9				
	Cheyyar anicut system	12·4	10·6				
	Alliabad anicut	2·3	1·5				
Chittoor	Poiney anicut	1·4	0·4	61·9	43·8	3·1	7·4
Salem	Barur tank	3·9	2·2	100·2	37·9	95·9	43·1
	Penukondapuram tank	0·2	..				
Coimbatore	Kalingarayan anicut	12·2	9·4	71·1	23·4	352·3	57·8
	Kodiveri anicut	20·2	3·6				
	Amaravati system	15·2	10·9				
Tiruchirappalli	South bank canal system	32·2	10·4	68·1	36·7	95·0	40·0
	Amaravati system	19·5	8·4				
	Nandayar channel	7·0	2·7				
	Cauvery canals	57·6	31·4				
Tanjore	Cauvery canals	907·2	94·5	33·6	3·3	..	..
	Lower Coleroon anicut	22·3	2·4				
Ramanathapuram	None	..	..	18·6	10·4	44·8	4·4
Madurai	Periyar system	182·6	51·0	137·9	53·9	244·3	33·6
Tirunelveli	Srivaikuntam anicut	24·0	15·3	113·9	56·7	63·4	28·6
	Marudur Project	16·5	15·5				
	Other works	35·5	34·2				

APPENDIX VI.

Statement of monthly average rainfall in the Province.

Name of district. (1)	January. (2)	February. (3)	March. (4)	April. (5)	May. (6)	June. (7)	July. (8)	August. (9)	September. (10)	October. (11)	November. (12)	December. (13)	Total. (14)
North Circars—													
Visakhapatnam	0·3	0·7	0·6	1·1	2·7	4·9	5·7	6·7	7·7	7·4	3·0	0·6	41·4
East Godavari	0·2	0'4	0·4	0·7	1·9	5·0	6·9	6·2	6·9	8·5	4·3	0·4	41·8
West Godavari	0·2	0·4	0·4	0·7	1·8	5·1	7 8	7·1	7·0	6·8	3·2	0·2	40·7
Krishna	0·2	0·4	0·4	0·7	1·5	4·4	7·0	6·5	6·2	6·1	3·3	0·3	37·0
Guntur	0·3	0·4	0·3	0·6	1·6	3·3	4·6	4·9	5·7	6·2	4·0	0·5	32·4
Average ..	0·2	0·5	0·4	0·8	1·9	4·5	6·4	6·3	6·7	7·0	3·6	0·4	38·7
Deccan—													
Kurnool	0 1	0·2	0 2	0·7	1 4	2·6	3·8	4·0	5·3	3·8	1·8	0·3	24·2
Bellary	0·1	0·2	0 2	0·8	2 0	2 3	2·6	3·5	5·3	3·8	1·4	0·2	22·4
Anantapur	0·1	0·2	0 2	0·8	2 0	2 1	2 2	3·3	5·3	4·0	1·9	0·3	22·4
Cuddapah	0·3	0·1	0 2	0·7	1 6	2·4	3·2	4·0	5 0	5·0	3·7	0·9	27·1
Average ..	0·2	0 2	0 2	0·8	1·8	2·4	3 0	3·7	5·2	4·2	2·2	0·4	24·0
The Carnatic—													
South Arcot	1·7	0 6	0·5	1·1	1·9	1·8	2·9	5·4	5 7	8·9	10·9	5·4	46·8
Chingleput	1·3	0 5	0·4	0·6	1·4	2 0	3·5	5·0	5·2	10·2	12·1	4·6	46·8
Nellore	1·0	0 3	0·3	0 5	1·4	1·6	2·6	2·9	4·1	8·9	9·3	2·6	35·5
Average ..	1·3	0 5	0·4	0·7	1·6	5'4	3·0	4·4	5·0	9·3	10·8	4·2	43·0
The Central districts—													
North Arcot	0·9	0 3	0 1	0·9	2·6	2 4	3·4	5·3	6·5	6·5	6·4	2·3	37·9
Chittoor	0·7	0·4	0·4	1·0	2·4	2 4	3·0	4·1	5·4	6·1	6·0	1·8	33·7
Salem	0·4	0·3	0·5	1·7	4·1	2·2	2·5	4·3	5·3	6·1	4·0	1·2	32·6
Coimbatore	0 5	0·4	0·7	2·1	3·4	1·4	1·5	2·1	2·9	6·6	4·4	1·4	27·4
Tiruchirappalli	1·0	0 4	0·5	1·7	3·3	1·4	1·6	3·7	4·9	7·1	5·9	2·7	34·2
Average ..	0·7	0 4	0 5	1·5	3·2	2 0	2·4	3·9	5·0	6·5	5·3	1 9	33·2
Southern districts—													
Tanjore	2·2	0·7	0·7	1·5	2 0	1·4	1·9	3·8	4·2	8 2	11·6	6 9	45 1
Madurai	1·0	0·6	0 8	2·4	2·9	1·3	1·4	2·7	3·5	7·3	6·1	2·3	32·3
Ramanathapuram	1·5	0·8	0 9	2·1	2·0	0·9	1·2	2·4	2·8	7·1	7·1	3·5	32·3
Tirunelveli	1·8	1·2	1 5	2·1	1·4	0'8	0·7	0·8	1·1	6·7	7·9	4·4	30·4
Average ..	1·6	0·8	1·0	2·0	2·1	1·1	1·3	2·4	2·9	7·3	8·2	4·3	35·0
West Coast—													
Malabar	0·3	0·3	0·8	3·4	8·1	30·4	33·9	18·6	8·3	10 6	5·4	1·0	121·1
South Kanara	0·2	0·1	0·2	1·6	5·9	39·8	47·5	28·7	12·4	9·2	3·2	0·6	149·4
Average ..	0·3	0·2	0·5	2·5	7·0	35·1	40·7	23·7	10·4	9·9	.. 4·3	0·8	135·3
Nilgiris—													
Nilgiris	1·3	1·0	1·4	3·6	6·0	9·4	14·5	10·6	7·1	10·0	6·9	2·6	74·4
Average ..	1·3	1·0	1·4	3·6	6·0	9·4	14·5	10·6	7·1	10·0	6·9	2·6	74·4

APPENDIX VII.

Growth of population in Madras State, 1891–41.

Names of districts. (1)	Population in 1891. (2)	Population in 1901. (3)	Population in 1911. (4)	Population in 1921. (5)	Population in 1931. (6)	Population in 1941. (7)
1 Visakhapatnam	2,788,031	2,983,213	3,134,820	3,168,216	3,484,703	3,845,944
2 East Godavari	1,331,350	1,466,179	1,652,859	1,673,968	1,920,582	2,161,868
3 West Godavari	765,245	860,960	980,323	1,051,442	1,223,056	1,380,088
4 Krishna	760,793	883,178	1,017,212	1,081,872	1,254,208	1,444,294
5 Guntur	1,316,204	1,490,635	1,697,551	1,809,574	2,035,660	2,277,288
6 Nellore	1,240,241	1,274,831	1,328,152	1,385,553	1,486,222	1,617,026
7 Cuddapah	882,762	880,080	893,938	887,929	949,397	1,056,507
8 Kurnool	817,811	872,070	935,259	914,890	1,024,961	1,146,250
9 Bellary	880,950	947,214	969,436	862,370	969,774	1,051,235
10 Anantapur	862,640	933,757	963,223	955,917	1,050,411	1,171,419
11 Madras	452,518	509,346	518,660	526,911	647,230	777,481
12 Chingleput	1,201,183	1,310,106	1,406,008	1,493,058	1,655,115	1,828,955
13 Chittoor	1,165,415	1,227,437	1,296,263	1,322,664	1,447,103	1,632,395
14 North Arcot	1,597,696	1,696,015	1,903,439	2,002,087	2,266,989	2,577,540
15 Salem	1,758,588	1,987,532	2,066,080	2,135,799	2,433,972	2,869,226
16 Coimbatore	1,776,569	1,958,716	2,094,066	2,196,083	2,445,064	2,809,648
17 South Arcot	1,957,448	2,105,809	2,362,566	2,320,085	2,454,507	2,608,753
18 Tanjore	2,230,930	2,248,051	2,366,045	2,329,915	2,385,920	2,563,375
19 Tiruchirappalli	1,640,457	1,716,340	1,862,446	1,937,318	1,944,315	2,194,091
20 Madurai	1,506,054	1,676,128	1,891,529	1,972,602	2,164,677	2,446,601
21 Ramanathapuram	1,458,946	1,524,713	1,664,101	1,718,187	1,888,955	1,979,643
22 Tirunelveli	1,535,442	1,663,312	1,796,191	1,907,314	2,046,907	2,244,543
23 Nilgiris	101,138	112,882	118,618	126,519	169,330	209,709
24 Malabar	2,648,172	2,795,738	3,015,099	3,098,871	3,533,944	3,929,425
25 South Kanara	1,056,081	1,134,713	1,195,227	1,247,368	1,372,241	1,523,516
Total	33,732,664	36,258,955	39,129,111	40,126,512	44,205,243	49,341,810

APPENDIX VIII.

Statement showing certain details of the statistics of population.

District.	Total population according to 1941 census.	Population supported by pastoral and agricultural occupation (according to 1931 census).	Percentage of population according to different occupations pursued by each class (according to 1931 census). Pastoral and agricultural.	Fishing and hunting.	Extraction of minerals.	Industry.	Transport.	Trade.	Public force.	Public administration.	Professional and literal arts.	Independent.	Domestic service.	Indefinite.	Unproductive.	Non-working dependants on the foregoing.	Total.	Approximate percentage of the rice-eating and millet-eating population. Rice eating.	Millet eating.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Visakhapatnam	3,845,944	989,346	31·1	0·9	..	7·9	0·2	2·3	0·1	0·4	0·4	..	12·3	8·9	0·9	34·6	100	70	30
East Godavari (P)	1,890,294	(P) 379,283	22·6	1·1	..	5·6	0·9	2·4	0·1	0·4	0·7	0·1	16·2	9·5	0·4	40·0	100	88	12
(A)	271,569	(A) 85,261																	
West Godavari	1,380,088	397,882	32·5	0·6	..	5·5	1·0	1·9	0·1	0 3	0·6	0·1	16·6	1·4	0·4	39·6	100	94	6
Krishna	1,444,294	361,807	28 9	0·4	..	5 5	1·6	2·1	0·1	0·4	0·8	0 2	16·5	1·8	0·5	41·2	100	72	28
Guntur	2,277,283	610,797	30 0	0·2	..	6 2	0·9	2·2	0·2	0·3	0·7	..	16·7	2·0	0·5	40·1	100	43	57
Kurnool	1,146,250	346,089	33·8	..	0·1	4·6	0·5	1·9	0 2	0·2	0·6	..	6·6	2·9	0·7	48·0	100	25	75
Bellary	1,051,235	..	32·7	..	..	4·1	0·4	2·1	0·1	0·3	0·4	..	16·3	3·0	40·6	..	100	21	79
Anantapur	1,171,419	371,720	35 4	..	..	4 7	0·6	2·0	0·1	0·3	0·5	..	14·8	1·2	0·5	39·9	100	34	66
Cuddapah	1,056,507	273,682	28·8	0·1	0·1	5 3	0 6	2·0	0·2	0·3	0·4	..	17·7	1·5	0·5	42·5	100	31	69
Nellore	1,617,026	434,181	32 6	0 4	0·2	4·5	0 9	1·9	0·1	0·2	0·5	..	18·3	0·7	0·4	39·3	100	39	61
Chingleput	1,823,955	357,290	21·6	0 4	..	4·8	0·8	2·1	0·1	0·4	0·7	0·1	14·7	7·0	0·4	46·9	100	87	13
South Arcot	2,608,753	656,825	26 8	0·4	..	2 7	0·4	1·4	0·1	0·2	0·5	..	15·1	6·4	0·1	45·9	100	63	37
Chittoor	1,632,395	476,005	32·9	..	..	3·5	0 7	1 8	0·1	0·2	0·4	..	20·8	1·1	0 3	38 2	100	47	53
North Arcot	2,577,540	579,080	25·5	..	..	3 9	0·5	1 8	0 1	0·4	0·5	0·1	12·5	6·2	0·2	48·8	100	65	35
Salem	2,869,226	742,890	30 5	..	0·1	4·7	0·3	1·5	0·2	0·3	0·4	..	12·3	4·6	0·2	44·9	100	35	65
Coimbatore	2,809,648	635,359	26·0	..	0·1	5·7	0·4	2·2	0·1	0·3	0·6	..	9·3	5·7	0 2	49·4	100	33	67
Tiruchirappalli	2,194,091	602,589	31·5	..	4·2	1·2	2 0	0·1	0·3	0·7	0·7	0·1	14·8	3·0	0·2	41·9	100	47	53
Tanjore	2,563,375	550,534	23·1	0·4	..	3·8	0 8	2·6	0·1	0·6	1·1	0·1	18 8	4·9	0·2	43 5	100	97	3
Ramanathapuram	1,979,643	407,245	22·1	0·2	..	4·1	0·2	2·5	0·1	0·2	0·6	..	15·7	6·8	0 2	47·3	100	55	45
Madurai	2,446,601	499,576	22·8	..	..	4·7	0·3	2·4	0·1	0·3	0·6	..	12·9	9·6	0·1	46·2	100	52	48
Tirunelveli	2,244,543	493,379	24·1	0·2	0·1	6·1	0·4	2·6	0·1	0·3	0·8	..	13·8	4·1	0 2	47·2	100	63	37
Malabar	3,929,425	461,445	13·1	0·6	..	5·8	0·7	2·8	0·1	0·2	1·1	..	3·3	11·0	0·1	61·2	100	99	1
South Kanara	1,523,516	386,727	28·2	0·8	..	4·0	0·8	2·6	..	0·2	0·9	..	16·2	2·6	0·1	43·6	100	..	..
The Nilgiris	209,709	46,709	27·6	..	..	3·8	1·3	1·8	0'6	0 2	0·9	0·2	14·5	11·5	0·2	37·4	100	79	21

(P) Plains. (A) Agency.

NOTE.—Figures in the statement are taken from Statistical Atlas, 1940–41.

APPENDIX IX.

Area sown with crops.

(Total for Madras State.)

Year.	Rice—Irrigated and unirrigated.	Sorghum—Irrigated and unirrigated.	Bajra—Irrigated and unirrigated.	Ragi—Irrigated and unirrigated.	Korra.	Varagu.	Samai.	Maize.	Other cereals.	Total cereals.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
1920–21	11,096,365	5,222,431	3,011,579	2,541,341	..	1,140,584	779,171	127,624	..	..
1921–22	11,279,503	5,572,510	3,197,487	2,493,421	1,390,765	1,219,880	775,565	96,541	710,073	26,735,745
1922–23	11,285,924	5,255,463	3,077,568	2,582,618	1,191,864	1,083,695	685,315	127,147	671,986	25,961,580
1923–24	10,516,701	4,647,085	2,645,076	2,592,199	1,583,308	1,039,954	713,762	138,576	745,757	24,622,418
1924–25	10,870,240	4,943,887	3,046,727	2,440,889	1,600,064	1,132,584	699,050	147,540	687,943	25,568,924
1925–26	11,822,646	4,546,216	3,074,173	2,330,782	1,563,934	1,150,175	754,289	137,834	680,223	25,560,272
1926–27	10,841,686	4,692,475	3,079,684	2,272,733	1,409,196	1,168,264	840,789	111,419	634,009	25,050,255
1927–28	10,929,615	4,829,650	3,275,676	2,301,700	1,663,855	1,096,863	783,492	162,873	587,142	25,630,866
1928–29	11,018,984	4,614,579	3,067,294	2,254,014	1,559,734	1,102,240	804,865	118,921	597,488	25,138,119
1929–30	11,262,067	5,174,030	2,888,317	2,269,649	1,370,762	1,012,085	878,340	117,237	673,294	25,645,781
1930–31	11,677,529	4,761,209	2,912,573	2,165,512	1,593,556	974,859	798,636	141,532	633,316	25,666,722
1931–32	11,537,733	4,830,678	2,877,161	2,200,674	1,428,839	1,118,182	746,833	110,184	639,960	25,490,244
1932–33	11,533,697	4,534,288	2,817,017	2,168,486	1,801,650	1,179,917	776,625	101,247	574,008	25,486,935
1933–34	11,703,788	4,411,554	2,558,562	2,123,968	1,623,045	1,134,761	736,686	107,590	595,985	24,995,939
1934–35	11,055,587	5,142,734	2,697,189	2,156,752	1,498,441	1,014,174	665,761	69,094	558,016	24,857,748
1935–36	10,478,804	5,102,324	2,712,207	1,802,091	1,552,397	1,050,636	502,667	75,424	551,232	23,827,282
1936–37	9,889,532	5,120,957	2,767,932	1,788,939	1,259,255	891,957	557,416	80,541	582,957	22,939,486
1937–38	10,140,831	4,599,444	2,571,988	1,618,118	1,298,531	934,055	518,948	72,026	549,999	22,803,940
1938–39	9,844,388	4,913,710	2,717,545	1,639,258	1,786,606	1,002,284	548,594	64,218	493,157	23,009,760
1939–40	9,884,316	5,052,465	2,796,073	1,640,892	1,592,478	879,495	587,342	74,635	552,079	23,009,775
1940–41	10,744,393	4,667,968	2,558,957	1,752,276	1,533,898	927,897	541,965	68,079	547,494	23,842,927
1941–42	10,212,422	4,904,941	2,492,181	1,813,534	1,614,299	1,109,481	679,022	65,727	616,042	23,507,649
1942–43	10,382,419	4,849,633	2,658,253	1,823,285	1,488,171	1,111,693	579,867	59,902	524,255	23,477,478
1943–44	10,925,131	4,990,125	2,685,087	1,748,891	1,665,791	950,708	559,271	63,213	540,856	24,129,018
1944–45	11,013,530	4,645,257	2,442,320	1,677,049	1,474,606	897,030	553,902	51,846	548,959	23,804,499
1945–46	10,202,580	4,149,927	2,317,157	1,587,201	1,618,357	924,171	497,004	39,306	498,330	21,884,088
1946–47	10,986,124	4,527,427	2,366,188	1,532,739	1,609,679	798,859	468,803	48,328	469,121	22,807,268
1947–48	10,484,149	4,211,008	2,238,989	1,481,591	1,563,860	888,928	438,683	47,841	454,868	21,759,407
1948–49	10,430,382	4,777,373	2,359,206	1,609,484	1,704,930	938,173	440,660	67,129	477,720	22,806,059

NOTE.—Particulars for the merged States of Banganapalli, Sandur and Pudukkottai are included in the districts of Kurnool, Bellary and Tiruchirappalli respectively, for the year 1948–49.

APPENDIX IX—*cont.*

Area sown with crops—cont.

(Total for Madras State)—*cont.*

Year.	Greengram—Irrigated and unirrigated.	Redgram.	Blackgram.	Bengalgram.	Horsegram.	Other pulses.	Total pulses.	Chillies.	Other condiments and speices.	Total condiments and speices.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
1920–21	363,088	223,637	218,342	93,789	1,969,010	..	..	301,799	..	668,780
1921–22	350,135	267,153	186,535	112,017	1,615,761	255,170	2,786,771	316,152	388,922	705,074
1922–23	372,565	248,100	182,595	126,804	1,825,149	232,383	2,987,596	345,180	399,526	744,706
1923–24	373,075	212,600	174,873	105,943	1,622,160	197,773	2,688,424	306,100	408,682	714,782
1924–25	415,013	263,989	168,550	109,092	1,648,728	196,342	2,801,714	305,106	358,163	663,269
1925–26	352,551	222,376	165,896	118,629	1,837,367	182,591	2,879,410	290,068	376,763	666,831
1926–27	359,663	218,083	167,418	60,180	1,710,953	184,452	1,700,749	347,078	325,539	672,831
1927–28	401,083	266,802	176,025	73,785	1,559,386	178,527	2,655,608	334,653	326,857	661,510
1928–29	401,358	240,080	180,523	74,110	1,748,872	182,430	2,827,373	268,003	388,371	656,374
1929–30	484,776	223,537	189,750	75,242	2,116,657	214,478	3,304,440	243,296	340,881	584,177
1930–31	510,364	275,314	196,375	84,896	1,918,121	233,088	3,218,158	307,450	316,769	624,219
1931–32	552,263	231,261	200,589	105,112	1,805,309	245,578	3,140,112	330,927	397,468	728,395
1932–33	559,728	288,898	229,361	89,802	1,760,135	283,227	3,211,151	172,491	394,148	666,639
1933–34	519,681	277,193	221,150	101,564	1,659,297	273,175	3,052,060	295,335	380,228	675,563
1934–35	496,640	270,027	216,424	115,390	1,664,847	240,753	3,006,081	453,084	399,596	853,505
1935–36	472,972	305,312	191,733	75,496	1,644,729	245,348	2,935,590	338,590	338,281	345,107
1936–37	423,893	285,029	188,197	82,884	1,759,086	244,803	2,983,892	244,687	327,517	572,204
1937–38	383,710	266,960	202,566	52,240	1,647,336	243,002	2,795,874	279,909	321,662	601,571
1938–39	420,350	306,784	190,448	50,806	1,216,660	240,637	2,425,685	334,780	311,211	645,991
1939–40	389,050	305,863	192,326	65,650	1,503,712	235,078	2,691,669	326,915	359,243	686,158
1940–41	407,236	333,153	191,674	66,412	1,575,928	232,861	2,807,264	304,206	371,841	676,047
1941–42	422,432	269,746	215,253	58,124	1,702,850	246,731	2,915,136	289,899	346,696	636,595
1942–43	509,110	389,997	277,632	50,823	1,446,934	275,888	2,980,834	319,223	321,551	640,774
1943–44	516,116	338,763	291,355	65,543	1,650,076	247,420	3,109,323	339,797	325,970	665,767
1944–45	491,880	332,446	306,940	79,539	1,550,353	244,487	3,005,645	285,122	328,809	613,931
1945–46	448,684	335,564	307,604	66,675	1,352,923	280,436	2,791,886	290,509	386,665	675,174
1946–47	472,739	363,021	296,592	100,432	1,442,995	259,744	2,935,523	365,061	403,890	768,951
1947–48	461,071	337,464	291,125	84,262	1,868,770	232,931	2,775,623	365,256	325,980	691,256
1948–49	452,326	359,183	295,580	102,644	1,452,205	283,572	2,945,510	336,022	301,136	637,158

APPENDIX IX—*cont.*

Area sown with crops—cont.

(Total for Madras State)—*cont.*

Year.	Sugarcane.	Sugar (others).	Total Sugar.	Mangoes.	Plantains.	Other fruits and vegetables including root crops.	Total fruits and vegetables including root crops.	Miscellaneous food crops.	Total food crops.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
1920–21	103,308	83,616	186,924	218,629	123,547	632,137	..	41,819	37,553,068
1921–22	119,313	76,408	195,721	235,201	130,013	289,667	654,881	50,028	31,128,220
1922–23	131,095	80,300	211,395	236,259	126,526	314,107	676,892	48,403	30,630,572
1923–24	121,298	81,207	202,505	237,479	124,046	290,149	651,674	72,019	28,951,822
1924–25	110,360	87,148	197,508	235,805	117,298	315,312	668,415	54,664	29,954,494
1925–26	112,821	81,535	194,356	239,606	122,114	316,934	678,654	54,487	30,034,010
1926–27	114,495	83,705	198,200	244,331	125,363	312,662	682,356	49,626	29,353,803
1927–28	105,950	83,060	189,010	237,581	129,142	306,426	673,149	51,118	29,861,261
1928–29	89,075	84,756	173,831	243,386	127,095	307,291	677,772	42,664	29,516,113
1929–30	98,107	84,306	182,413	259,389	129,635	312,003	701,027	40,924	30,458,762
1930–31	114,877	91,080	205,957	249,094	138,892	303,624	691,610	63,367	30,470,030
1931–32	116,105	90,796	206,901	260,187	144,167	336,721	741,075	68,422	30,375,149
1932–33	120,921	88,151	209,072	266,797	144,838	325 248	736,878	74,828	30,385,503
1933–34	121,650	89,479	211,129	271,212	153,059	324,028	748,299	71,432	29,754,422
1934–35	125,310	91,070	216,380	278,455	154,012	332,555	765,022	63,209	29,761,120
1935–36	123,361	86,431	209,792	256,456	137,214	306,138	699,806	40,626	28,396,484
1936–37	119,650	91,252	210,902	244,945	132,777	361,639	739,861	29,881	27,475,726
1937–38	97,965	92,622	190,587	240,652	138,480	312,374	691,506	39,801	26,623,219
1938–39	98,262	95,803	194,065	249,579	138,117	326,655	714,351	49,276	27,039,128
1939–40	137,633	90,518	228,151	250,938	136,717	330,358	701,013	47,887	27,864,653
1940–41	161,716	90,991	252,707	254,490	136,455	327,336	718,281	29,196	27,826,422
1941–42	109,527	88,360	197,887	262,573	138,324	355,351	756,188	32,739	28,046,194
1942–43	121,691	88,022	209,713	254,099	132,933	353,970	741,002	38,100	28,007,451
1943–44	154,650	86,786	241,436	248,662	130,782	356,099	735,543	46,484	28,927,570
1944–45	155,596	85,119	240,715	244,709	141,172	360,128	746,009	57,398	27,968,197
1945–46	160,700	79,900	240,600	247,310	157,184	417,168	821,662	60,369	26,425,724
1946–47	202,828	88,268	291,096	243,469	162,781	385,412	791,662	83,856	27,628,356
1947–48	272,680	80,126	352,806	231,000	168,654	398,388	798,042	32,722	26,409,836
1948–49	175,675	75,661	251,836	254,866	159,790	412,032	826,588	52,581	27,518,182

APPENDIX IX—*cont.*

Area sown with crops—cont.

(Total for Madras State)—*cont.*

Year. (1)	Groundnut. (2) ACS.	Gingelly. (3) ACS.	Castor. (4) ACS.	Coconut. (5) ACS.	Other oil seeds. (6) ACS.	Total oil seeds. (7) ACS.	Cotton. (8) ACS.	Other fibres. (9) ACS.	Total fibres. (10) ACS.
1920–21	1,599,738	752,622	*390,668	544,747	182,593	..	2,121,628	154,915	2,277,221
1921–22	1,459,122	778,447	380,629	559,404	194,989	3,372,591	1,782,981	159,063	1,942,044
1922–23	1,754,834	727,334	327,131	543,263	199,589	3,551,651	2,322,928	162,203	2,485,131
1923–24	1,811,790	695,758	339,020	520,552	217,471	3,584,591	2,631,621	173,600	2,805,221
1924–25	1,904,119	783,869	358,685	525,445	170,510	3,742,628	2,865,631	203,470	3,069,101
1925–26	2,598,609	790,670	377,863	555,465	172,862	4,495,460	2,887,443	244,242	3,131,685
1926–27	2,680,156	681,890	385,023	552,815	168,227	4,468,111	2,203,688	184,835	2,388,523
1927–28	3,336,536	836,921	360,152	557,102	169,608	5,260,319	2,099,718	173,401	2,273,119
1928–29	3,679,349	759,716	344,373	570,330	161,886	5,515,654	2,464,775	176,252	2,641,027
1929–30	3,209,315	773,119	256,225	576,083	173,107	4,987,849	2,476,664	163,288	2,630,951
1930–31	3,571,978	745,872	283,238	565,971	164,463	5,331,522	2,041,284	168,290	2,209,574
1931–32	2,635,427	747,053	330,106	539,031	174,053	4,425,670	2,204,505	149,231	2,353,737
1932–33	3,516,679	835,819	355,373	556,827	158,130	5,422,828	1,949,664	179,286	2,128,950
1933–34	3,779,365	836,145	304,668	561,555	166,478	5,648,211	2,155,942	161,224	2,327,166
1934–35	2,850,934	653,023	278,131	586,486	184,225	4,052,799	2,304,055	130,868	2,434,923
1935–36	2,525,304	750,112	257,465	583,449	74,672	4,191,002	2,664,254	181,725	2,845,979
1936–37	3,495,023	802,143	263,870	584,613	76,234	5,221,883	2,487,052	159,177	2,646,229
1937–38	4,679,596	794,875	246,718	586,130	68,064	6,353,383	2,543,306	237,461	2,780,767
1938–39	3,771,588	876,397	270,278	585,424	64,462	5,568,149	1,928,714	229,628	2,158,342
1939–40	3,617,600	734,496	266,051	608,607	60,772	5,287,526	2,196,284	223,733	2,420,017
1940–41	3,922,497	786,079	266,786	598,427	60,321	5,634,110	2,412,857	202,054	2,614,911
1941–42	2,784,441	693 070	243,954	596,147	62,420	4,380,032	2,540,096	254,174	2,795,170
1942–43	3,382,126	839,519	277,238	598,054	41,258	5,138,195	2,209,889	249,383	2,459,272
1943–44	3,550,018	696,838	279,032	605,764	83,168	5,214,815	2,187,278	229,957	2,417,235
1944–45	4,299,598	616,142	284,759	615,518	90,435	5,906,446	1,670,141	208,849	1,878,990
1945–46	4,165,385	599,056	235,263	613,997	76,390	5,690,021	1,611,338	220,290	1,831,628
1946–47	4,121,394	672,870	229,244	618,813	60,101	5,702,422	1,566,530	156,118	1,722,618
1947–48	4,066,830	638,367	240,823	615,983	73,997	5,636,000	1,297,647	125,636	1,423,283
1948–49	3,698,830	612,819	229,850	622,564	61,549	5,225,612	1,632,639	189,373	1,822,012

APPENDIX IX—*cont.*

Area sown with crops—cont.

(Total for Madras State)—*cont.*

Year. (1)	Indigo. (2)	Other dyes. (3)	Total dyes. (4)	Tobacco. (5)	Other drugs and narcotics. (6)	Total drugs and narcotics. (7)	Fodder crops. (8)	Miscellaneous non-food crops. (9)	Total non-food crops (10)
	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.	ACS.
1920–21	112,138	8,941	121,079	201,062	147,919	453,280	298,872	251,355	..
1921–22	197,282	2,620	199,902	203,088	256,445	459,533	292,110	138,828	6,405,008
1922–23	141,316	4,990	146,306	213,689	233,997	447,686	347,593	153,552	7,181,899
1923–24	91,090	8,439	99,529	219,849	235,438	455,279	370,794	156,621	7,472,035
1924–25	70,226	2,220	72,446	260,707	243,045	503,752	423,888	157,308	7,969,123
1925–26	77,627	2,983	80,610	244,389	251,129	495,518	388,284	162,920	8,754,486
1926–27	53,639	4,602	58,241	332,155	243,893	476,048	454,641	167,765	8,013,329
1927–28	40,181	4,574	44,755	275,768	259,749	535,517	422,846	160,261	8,696,817
1928–29	48,573	6,710	55,283	255,229	253,174	508,403	407,426	135,238	9,263,031
1929–30	52,761	10,732	63,493	256,703	253,346	510,049	417,334	181,815	8,800,491
1930–31	46,905	6,023	52,928	242,644	262,440	505,088	449,865	174,191	8,723,168
1931–32	37,239	5,237	42,476	268,815	276,484	545,295	464,978	137,272	7,969,428
1932–33	46,121	5,958	52,079	256,114	282,584	538,698	483,666	151,885	8,778,106
1933–34	30,120	2,957	33,077	247,826	287,533	535,359	483,983	148,197	9,157,993
1934–35	54,245	1,837	56,082	292,294	292,270	584,564	493,648	155,374	7,777,390
1935–36	26,390	1,317	27,707	279,887	289,223	569,110	463,530	135,015	8,232,343
1936–37	30,098	902	31,000	253,160	287,008	540,168	523,753	149,658	9,121,686
1937–38	23,167	1,305	24,472	294,232	282,772	577,004	413,157	145,934	10,294,717
1938–39	28,576	1,658	30,234	320,174	282,791	602,925	431,865	130,433	8,921,948
1939–40	30,386	1,681	32,067	307,172	284,774	591,946	453,553	130,470	8,915,190
1940–41	55,062	1,819	56,881	310,564	295,239	605,843	459,455	146,102	9,517,302
1941–42	39,059	3,115	42,174	333,880	296,377	630,257	388,602	137,166	8,873,401
1942–43	40,756	2,435	43,191	284,787	291,438	576,225	372,845	143,024	8,732,752
1943–44	38,771	714	39,485	238,219	287,182	525,401	430,705	149,400	6,777,041
1944–45	47,845	4,414	52,259	328,185	288,334	616,519	459,653	117,195	9,081,175
1945–46	42,378	2,581	44,954	363,036	289,395	652,431	463,463	166,195	8,848,692
1946–47	26,940	3,331	30,271	303,997	286,570	590,567	562,794	175,910	8,784,612
1947–48	22,867	3,172	26,039	298,759	287,954	587,713	394,144	161,725	8,222,904
1948–49	17,424	2,808	20,232	322,356	269,528	591,884	442,870	175,884	8,278,494

NOTE.—Particulars for the merged States of Banganapalli, Sandur and Pudukkottai are included in the districts of Kurnool, Bellary and Tiruchirappalli respectively for the year 1948–9.

APPENDIX X.

Percentage of area under main crops.

Year.	Rice.	Sorghum.	Bajra.	Ragi.	Korra.	Cereals.	Pulses other than horse gram.	Food crops.	Groundnut.	Gingelly.	Castor.	Coconut.	Cotton.	Indigo.	Tobacco.	Non-food crops.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
1922–23	30·0	14·0	8·0	7·0	3·0	69·0	3·0	81·0	5·0	2·0	1·0	1·0	6·0	..	1·0	19·0
1923–24	29·0	13·0	7·0	7·0	4·0	68·0	3·0	79·0	5·0	2·0	1·0	1·0	7·0	..	1·0	21·0
1924–25	29·0	13·0	8·0	6·0	4·0	67·0	3·0	79·0	5·0	2·0	1·0	1·0	8·0	..	1·0	21.0
1925–26	29·0	12·0	8·0	6·0	4·0	66·0	3·0	77·5	7·0	2·0	1·0	1·0	7·0	..	1·0	22·5
1926–27	29·0	13·0	8·0	6·0	4·0	67·0	3·0	79·0	7·0	2·0	1·0	1·0	6·0	..	1'0	21·0
1927–28	28·0	13·0	8·0	6·0	4·0	66·0	3·0	77·0	9·0	2·0	1·0	1·0	5·0	..	1·0	23·0
1928–29	28·0	12·0	8·0	6·0	4·0	65·0	3·0	76·0	9·0	2·0	1·0	1·0	6·0	..	1·0	24·0
1929–30	29·0	13·0	7·0	6·0	3·0	65·0	3·0	78·0	8·0	2·0	1·0	1·0	6·0	..	1·0	22·0
1930–31	30·0	12·0	7·0	6·0	4·0	65·0	3·0	78·0	9·0	2·0	1·0	1·0	5·0	0·1	1·0	22·0
1931–32	30·0	13·0	8·0	6·0	4·0	66·0	3·0	79·0	7·0	2·0	1·0	1·0	6·0	..	1·0	21·0
1932–33	29·0	12·0	7·0	6·0	5·0	65·0	4·0	78·0	9·0	2·0	1·0	1·0	5·0	..	1·0	22·0
1933–34	30·0	11·3	6·6	5·5	4·2	64·2	3·6	76·4	9·7	2·2	0·8	1·5	5·5	0·1	0·6	23·6
1934–35	29·5	13·7	7·2	5·8	4·0	66·2	3·6	79·3	6·3	1·7	0·7	1·6	6·1	..	0·8	20·7
1935–36	28·6	13·9	7·4	4·9	4·2	65·1	3·5	77·5	6·9	2·4	0·7	1·6	7·3	0.1	0·8	22·5
1936–37	27·0	14·0	7·6	4·9	3·4	62·7	3·3	75·1	9·5	2·2	0·7	1·6	6·8	0·1	0·7	24·9
1937–38	27·5	12·5	7·0	4·4	3·5	60·4	3·1	72·1	12·6	2·1	0·7	1·6	6·9	0·1	0·8	27·9
1938–39	27·4	13·7	7·6	4·6	5·0	64·0	3·4	75·2	10·5	2·4	0·8	1·6	5·4	0·1	0·9	24·8
1939–40	27·2	13·9	7·7	4·5	4·4	63·4	3·3	75·4	10·0	2·0	0·7	1·7	6·1	0·1	0·8	24·6
1940–41	28·8	12·5	6·9	4·7	4·1	62·5	3·3	74·5	10·5	2·1	0·7	1·6	6·5	0·1	0·8	25·5
1941–42	28·0	13·5	6·8	5·0	4·4	64·6	3·3	77·0	7·7	1·9	0·7	1·6	7·0	0·1	0·9	23·0
1942–43	28·3	13·2	7·2	5·0	4·0	63·9	3·9	76·2	9·2	2·3	0·8	1·6	6·0	0·1	0·8	23·8
1943–44	29·0	13·2	7·1	5·6	4·4	64·0	3·9	76·7	9·4	1·9	0·7	1·6	5·8	0·4	0·6	23·3
1944–45	29·8	12·6	6·6	4·5	4·0	63·0	3·9	75·6	11·6	1·7	0·8	1·7	4·5	0·1	0·9	24·4
1945–46	28·9	11·8	6·6	4·5	4·6	61·9	4·1	74·9	11·8	1·7	0·7	1·8	4·6	0·1	1·9	25·1
1946–47	30·1	12·4	6·5	4·2	4·4	62·6	4·1	75·9	11·3	1·9	0·6	1·7	4·3	0·1	0·8	24·1
1947–48	30·1	12·1	6·4	4·3	4·5	62·8	4·0	76·2	11·7	1·8	0·7	1·9	3·7	0·1	0·8	23·8
1948–49	29·1	13·3	6·6	4·5	4·8	63·7	4·2	76·9	10·3	1·7	0·6	1·7	4·6	..	0·9	23·1

APPENDIX XI.

Area sown with crops.

Rice (Irrigated and unirrigated) in 000 acres.

(1)	Vizakhapatnam. (2)	East Godavari. (3)	West Godavari. (4)	Krishna. (5)	Guntur. (6)	Kurnool. (7)	Bellary. (8)	Anantapur. (9)	Cuddapah. (10)	Nellore. (11)	Chingleput. (12)	South Arcot. (13)
1921–22	464	540		1,115	381	72	43	111	133	400	663	547
1922–23	416	480		1,108	378	60	32	76	100	397	732	592
1923–24	1,061	514		1,104	348	57	26	86	71	356	643	544
1924–25	1,144	560	631	526	369	53	29	84	100	392	652	523
1925–26	1,160	603	662	531	385	64	31	69	125	466	731	557
1926–27	1,155	685	681	538	400	58	28	83	94	350	638	540
1927–28	1,166	620	696	556	386	68	27	90	85	390	614	525
1928–29	1,187	638	658	563	392	62	28	73	94	373	686	574
1929–30	1,165	595	665	564	393	46	30	111	104	396	709	598
1930–31	1,117	587	662	558	394	65	28	134	141	466	722	594
1931–32	1,127	666	685	570	401	70	30	66	111	429	752	613
1932–33	1,117	653	684	583	404	60	37	103	74	364	725	627
1933–34	1,113	633	676	577	396	71	41	138	100	422	725	610
1934–35	1,136	683	677	567	395	71	33	42	70	376	667	556
1935–36	712	664	661	552	378	70	31	130	118	379	675	558
1936–37	812	699	700	568	399	70	33	100	87	384	615	538
1937–38	756	686	688	562	398	71	27	90	107	403	737	573
1938–39	738	700	707	581	406	77	33	176	118	360	590	536
1939–40	677	658	666	596	423	80	31	109	115	407	614	550
1940–41	783	716	702	613	426	86	34	149	148	474	702	591
1941–42	643	685	622	590	432	65	28	122	115	427	725	602
1942–43	769	691	732	634	453	68	30	93	104	412	634	607
1943–44	720	689	728	639	445	72	31	96	159	469	701	612
1944–45	738	694	741	632	451	92	34	119	141	480	681	598
1945–46	724	707	754	659	452	76	30	70	104	376	580	589
1946–47	791	659	756	658	433	89	31	139	140	471	716	602
1947–48	791	698	773	662	464	97	33	134	121	404	547	572
1948–49	784	681	745	658	465	90	34	108	105	414	546	586

(1)	Chittoor. (14)	North Arcot. (15)	Salem. (16)	Coimbatore. (17)	Tiruchirappalli. (18)	Tanjore. (19)	Madurai. (20)	Ramanathapuram. (21)	Tirunelveli. (22)	Malabar. (23)	South Kanara. (24)	The Nilgiris. (25)
1921–22	190	458	221	109	327	1,108	353	429	331	859	593	5
1922–23	190	497	205	109	336	1,131	361	431	355	880	596	6
1923–24	187	343	121	103	287	1,107	307	410	353	882	582	6
1924–25	172	387	115	104	249	1,052	289	404	353	891	581	6
1925–26	176	462	92	100	238	1,097	298	392	361	898	580	6
1926–27	168	377	93	101	250	1,103	312	286	380	884	579	6
1927–28	176	383	104	101	251	1,091	303	287	362	881	581	6
1928–29	183	449	94	96	247	1,081	303	298	344	871	575	6
1929–30	196	423	113	100	271	1,117	326	382	387	877	577	6
1930–31	302	537	171	118	305	1,099	341	396	368	879	583	6
1931–32	247	585	144	106	298	1,086	329	397	340	877	588	6
1932–33	191	528	186	117	335	1,099	355	435	336	869	588	6
1933–34	205	488	202	122	337	1,118	365	456	368	892	587	6
1934–35	178	436	154	102	288	1,123	321	377	281	865	576	5
1935–36	243	528	147	90	291	1,149	288	387	292	865	582	6
1936–37	206	439	131	93	292	1.171	324	383	367	892	582	6
1937–38	232	546	130	94	325	1,197	329	405	325	865	588	6
1938–39	200	465	169	94	326	1,202	291	329	291	860	589	6
1939–40	232	492	198	93	341	1,213	298	338	293	862	598	6
1940–41	248	551	241	114	355	1,229	350	391	351	881	602	6
1941–42	210	515	209	118	357	1,265	343	369	360	870	582	6
1942–43	165	449	207	116	375	1,295	343	385	347	888	576	7
1943–44	316	622	228	123	309	1,328	360	361	374	890	592	8
1944–45	277	541	247	146	375	1,361	399	451	368	846	599	7
1945–46	177	433	190	134	330	1,359	342	345	346	825	598	6
1946–47	241	579	238	140	357	1,326	357	446	388	828	601	7
1947–48	191	452	227	142	347	1,320	409	330	313	806	594	6
1948–49	186	392	188	145	446	1,351	362	366	362	808	606	6

NOTE.—Particulars for the merged States of Banganapalli, Sandur and Pudukkottai, are included in the districts of Kurnool, Bellary and Tiruchirappalli respectively for the year 1948–49, in the case of all the crops.

APPENDIX XII.

Area sown with crops.

Sorghum (Irrigated and unirrigated) in 000 acress.

Year. (1)		Vizakhapatnam. (2)	East Godavari. (3)	West Godavari. (4)	Krishna. (5)	Guntur. (6)	Kurnool. (7)	Bellary. (8)	Anantapur. (9)	Cuddapah. (10)	Nellore. (11)	Chingleput. (12)	South Arcot. (13)
1921–22	..	63	65		326	391	734	1,120	415	302	363	9	47
1922–23	..	100	94		361	378	682	886	384	297	399	9	63
1923–24	..	124	120		384	378	584	580	303	338	363	8	65
1924–25	..	87	115	85	238	369	610	688	334	347	392	9	59
1925–26	..	81	98	66	240	358	521	699	248	270	395	9	65
1926–27	..	77	101	74	244	355	653	782	297	280	384	9	62
1927–28	..	85	108	76	254	404	586	705	285	270	425	10	72
1928–29	..	86	102	77	246	362	545	624	244	266	465	9	78
1929–30	..	96	130	86	245	378	674	852	362	352	452	9	80
1930–31	..	93	134	82	238	450	568	677	255	265	437	7	73
1931–32	..	81	96	59	234	391	581	748	352	301	428	6	75
1932–33	..	79	111	67	217	377	505	637	271	271	448	5	71
1933–34	..	72	99	61	208	436	522	612	229	283	421	7	69
1934–35	..	70	94	62	206	418	604	951	366	318	420	8	97
1935–36	..	67	91	69	222	415	591	672	339	345	415	9	94
1936–37	..	70	103	63	214	424	575	782	374	346	473	9	85
1937–38	..	72	99	52	185	345	485	710	295	302	448	7	91
1938–39	..	70	95	52	216	417	592	700	303	311	405	7	95
1939–40	..	72	103	60	206	423	568	639	297	337	435	11	103
1940–41	..	77	101	55	203	415	504	619	269	294	398	8	97
1941–42	..	92	117	75	266	443	674	662	293	335	375	6	84
1942–43	..	72	100	77	225	383	586	606	320	304	404	6	79
1943–44	..	74	97	72	224	439	624	719	354	307	382	5	79
1944–45	..	71	87	61	201	383	518	754	291	254	362	4	74
1945–46	..	61	82	61	210	380	448	554	234	238	370	4	79
1946–47	..	64	86	61	209	413	482	698	293	264	356	4	86
1947–48	..	51	70	54	201	465	478	662	248	239	321	4	60
1948–49	..	60	79	58	234	461	620	641	272	300	356	7	100

Year. (1)	Chittoor. (14)	North Arcot. (15)	Salem. (16)	Coimbatore. (17)	Tiruchirappalli. (18)	Tanjore. (19)	Madurai. (20)	Ramanathapuram. (21)	Tirunelveli. (22)	Malabar. (23)	South Kanara. (24)	The Nilgiris. (25)
1921–22	35	39	130	583	264	17	345	114	116	..	..	..
1922–23	27	44	136	567	241	17	261	111	113	2	..	1
1923–24	42	72	154	492	158	15	225	105	106	..	..	..
1924–25	37	65	163	520	242	16	341	102	112	..	..	..
1925–26	40	55	160	473	243	17	277	107	108	..	..	..
1926–27	26	45	158	433	210	15	238	106	128	..	..	..
1927–28	34	54	156	457	267	15	343	94	116	..	..	..
1928–29	41	60	184	501	273	16	234	82	107	..	..	..
1929–30	54	76	194	499	220	15	214	79	91	..	..	..
1930–31	42	81	198	468	261	14	258	71	75	..	..	..
1931–32	29	71	219	477	212	14	287	82	68	..	..	..
1932–33	32	58	173	473	268	15	283	76	76	..	..	..
1933–34	47	67	174	451	227	12	250	70	77	..	..	..
1934–35	47	90	212	557	236	10	186	76	93	..	..	..
1935–36	47	98	260	580	303	11	297	78	90	..	..	..
1936–37	38	79	252	555	268	8	237	81	85	..	..	..
1937–38	41	82	235	525	260	8	210	71	75	..	..	..
1938–39	49	71	251	502	271	9	329	82	88	4	.	1
1939–40	35	82	269	594	306	..	371	65	75	1	..	..
1940–41	39	88	242	538	265	..	277	77	101	1	..	..
1941–42	50	85	261	492	248	..	204	62	78	1	..	..
1942–43	72	86	256	562	264	..	282	71	94	1	..	..
1943–44	30	77	253	576	266	..	253	61	97	1	..	..
1944–45	27	62	274	498	287	..	297	55	84	1	..	..
1945–46	30	72	255	453	255	..	247	43	73	1	..	..
1946–47	36	78	262	474	251	..	236	49	72	1	..	..
1947–48	29	61	225	434	244	..	244	38	82	..	..	..
1948–49	34	79	251	504	294	..	305	43	78	1	..	..

APPENDIX XIII.

Area sown with crops.

Bajra (Irrigated and unirrigated) in 000 acres.

Year.	Vizakhapatnam.	East Godavari.	West Godavari.	Krishna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22 ..	171	40		64	267	81	107	162	125	97	15	129	177	142	411	447	293	12	54	181	185	..	..	..
1922–23 ..	187	32		57	263	71	76	135	118	91	18	137	178	154	393	397	305	12	62	181	181	..	..	..
1923–24 ..	190	39		41	205	72	97	114	105	82	11	77	148	68	323	330	302	6	65	173	176	..	..	..
1924–25 ..	194	44	13	34	237	69	102	159	125	115	15	98	175	148	420	438	275	7	47	153	163	..	..	..
1925–26 ..	189	39	13	35	230	66	129	161	114	87	16	103	173	116	395	449	287	9	87	156	203	..	..	..
1926–27 ..	191	35	9	36	248	74	118	172	124	105	14	87	164	111	432	457	289	7	72	136	188	..	..	..
1927–28 ..	198	38	13	42	254	83	137	174	129	140	17	130	171	142	405	470	290	8	64	178	177	..	..	..
1928–29 ..	201	45	13	37	236	68	105	160	120	113	17	104	174	115	408	409	300	11	66	158	197	..	..	..
1929–30 ..	210	41	14	40	186	59	99	94	94	105	15	99	148	118	375	415	332	12	79	151	194	..	..	..
1930–31 ..	217	42	12	37	197	72	122	169	123	108	16	85	165	110	395	385	272	9	61	145	158	..	..	..
1931–32 ..	209	46	13	40	229	65	97	146	125	104	17	102	160	110	364	337	296	9	65	162	169	..	..	..
1932–33 ..	210	44	11	38	197	63	130	175	109	111	14	92	153	97	360	376	272	8	43	136	166	..	..	..
1933–34 ..	207	45	12	32	169	59	96	147	115	107	11	90	158	89	298	327	271	7	33	120	153	..	..	..
1934–35 ..	203	42	9	25	199	74	112	158	136	102	18	120	171	136	312	227	269	6	54	161	152	..	..	..
1935–36 ..	198	58	10	23	182	70	117	162	137	123	17	86	172	96	333	302	252	7	43	170	150	..	..	..
1936–37 ..	218	49	10	19	204	63	115	164	115	105	15	103	164	94	330	335	271	7	60	162	165	..	..	..
1937–38 ..	188	48	6	14	189	62	110	137	101	105	17	100	141	92	318	329	269	6	35	148	161	..	..	..
1938–39 ..	208	52	10	20	179	68	135	174	123	98	12	107	154	79	309	352	271	8	29	159	178	..	..	..
1939–40 ..	174	51	9	18	170	60	138	184	129	107	20	110	168	95	352	373	265	8	44	146	175	..	..	..
1940–41 ..	189	52	10	19	159	53	94	151	105	104	18	109	153	97	300	303	246	6	51	151	187	..	..	..
1941–42 ..	189	56	11	25	158	65	133	156	101	101	13	97	135	71	266	290	242	6	45	157	174	..	..	..
1942–43 ..	180	59	16	22	188	72	125	166	108	105	14	100	150	84	296	302	251	7	40	164	210	..	..	..
1943–44 ..	180	68	15	23	198	64	133	180	124	126	18	93	162	75	309	286	262	6	45	138	190	..	..	..
1944–45 ..	177	57	7	16	185	61	154	165	97	108	10	81	116	62	281	304	215	5	43	120	175	..	..	..
1945–46 ..	167	46	8	16	201	63	147	167	91	105	10	97	117	60	254	266	220	5	47	98	131	..	..	..
1946–47 ..	159	45	7	16	158	62	158	172	100	117	14	103	129	66	244	265	241	4	55	93	157	..	..	..
1947–48 ..	161	46	7	14	191	73	163	177	104	110	8	86	117	61	211	254	209	3	41	60	146	..	..	..
1948–49 ..	181	43	9	14	191	69	153	180	101	115	13	96	138	64	218	257	218	3	42	96	158	..	..	..

APPENDIX XIV.

Area sown with crops.

Ragi (Irrigated and unirrigated) in 00 acres.

Year. (1)	Visakhapatnam. (2)	East Godavari. (3)	West Godavari. (4)	Krishna. (5)	Guntur. (6)	Kurnool. (7)	Bellary. (8)	Anantapur. (9)	Cuddapah. (10)	Nellore. (11)	Chingleput. (12)	South Arcot. (13)
1921–22 ..	1,915	372		224	253	315	343	1,127	790	735	954	1,062
1922–23 ..	2,610	300		165	271	338	391	1,085	833	833	958	1,199
1923–24 ..	4,768	388		226	356	268	355	1,095	711	773	852	1,131
1924–25 ..	4,526	362	88	103	289	285	314	1,186	762	1,003	966	1,186
1925–26 ..	4,594	296	52	83	197	198	324	966	649	735	994	1,178
1926–27 ..	4,935	282	62	60	225	190	295	988	610	804	861	1,015
1927–28 ..	4,970	309	60	79	198	225	271	935	774	1,001	916	1,156
1928–29 ..	5,051	286	62	93	195	219	257	1,016	726	988	891	1,023
1929–30 ..	5,278	332	60	72	225	301	232	834	847	939	799	1,002
1930–31 ..	5,287	255	45	73	203	240	230	913	529	750	770	923
1931–32 ..	5,102	293	81	94	190	229	222	940	648	802	722	920
1932–33 ..	5,077	280	64	95	174	226	229	1,003	728	821	742	858
1933–34 ..	5,018	190	53	74	149	251	223	850	685	828	787	872
1934–35 ..	5,065	192	36	72	141	233	284	912	805	1,063	920	960
1935–36 ..	2,604	218	44	60	181	243	281	957	630	1,021	817	806
1936–37 ..	2,840	199	46	59	168	244	267	989	804	975	931	903
1937–38 ..	2,311	208	39	45	168	210	249	903	640	770	821	749
1938–39 ..	2,376	228	46	41	167	219	265	956	509	737	959	757
1939–40 ..	2,194	222	67	40	162	250	258	1,021	684	840	856	823
1940–41 ..	2,271	232	65	79	162	213	251	972	538	819	987	948
1941–42 ..	2,556	299	67	87	187	282	273	993	688	787	812	808
1942–43 ..	2,613	292	127	100	185	206	260	966	667	823	966	824
1943–44 ..	2,551	272	94	91	185	234	307	1,026	608	823	942	738
1944–45 ..	2,325	228	62	64	160	206	276	976	593	849	731	728
1945–46 ..	2,150	185	46	42	138	202	257	963	543	933	675	746
1946–47 ..	1,767	146	41	36	116	198	229	938	502	928	783	729
1947–48 ..	1,639	159	39	40	164	206	241	913	584	855	774	699
1948–49 ..	1,852	166	59	38	165	221	258	951	652	964	891	886

Year. (1)	Chittoor. (14)	North Arcot. (15)	Salem. (16)	Coimbatore. (17)	Tiruchirappalli. (18)	Tanjore. (19)	Madurai. (20)	Ramanathapuram. (21)	Tirunelveli. (22)	Malabar. (23)	South Kanara. (24)	The Nilgiris. (25)
1921–22 ..	1,437	1,307	2.956	2,065	1,112	296	903	1,313	451	133	66	23
1922–23 ..	1,463	1,402	3,022	1,962	1,099	317	927	1,278	380	126	69	25
1923–24 ..	1,510	1,525	3,252	1,934	1,127	293	956	1,273	388	132	68	26
1924–25 ..	1,410	1,390	2,778	1,602	953	299	721	1,227	359	131	64	28
1925–26 ..	1,425	1,274	2,808	1,658	773	339	787	1,280	409	127	64	28
1926–27 ..	1,325	1,202	2,832	1,734	814	311	805	856	351	123	65	32
1927–28 ..	1,345	1,235	2,653	1,570	807	294	732	946	390	120	65	27
1928–29 ..	1,518	1,100	2,634	1,411	653	269	663	973	396	112	66	26
1929–30 ..	1,628	1,164	2,538	1,423	719	258	692	1,054	336	189	65	30
1930–31 ..	1,478	998	2,850	1,690	762	199	618	805	282	126	65	26
1931–32 ..	1,481	995	2,845	1,711	765	239	559	871	271	152	67	25
1932–33 ..	1,645	986	2,668	1,691	721	242	599	792	244	123	68	26
1933–34 ..	1,666	1,120	2,649	1,782	670	178	507	737	278	119	67	26
1934–35 ..	1,705	1,092	2,380	1,535	703	199	560	796	229	109	66	24
1935–36 ..	1,634	1,042	2,544	1,379	657	194	644	971	263	113	67	25
1936–37 ..	1,661	1,135	2,339	1,429	581	169	618	1,045	283	110	68	24
1937–38 ..	1,575	1,056	2,342	1,341	631	146	535	990	252	111	62	28
1938–39 ..	1,640	1,057	2,690	1,314	478	136	485	868	266	107	62	29
1939–40 ..	1,552	1,038	2,508	1,327	484	186	547	894	261	103	63	29
1940–41 ..	1,650	1,211	2,634	1,759	558	193	589	909	272	116	63	32
1941–42 ..	1,762	1,107	2,900	1,748	590	172	568	931	308	114	62	34
1942–43 ..	1,742	1,088	2,750	1,745	573	184	596	963	338	127	61	39
1943–44 ..	1,376	939	2,844	1,767	580	174	620	777	309	116	67	50
1944–45 ..	1,297	883	2,845	1,741	548	116	590	1,013	345	91	65	44
1945–46 ..	1,358	982	2,849	1,629	445	110	508	766	239	56	66	34
1946–47 ..	1,404	927	2,801	1,614	452	150	510	646	270	46	63	33
1947–48 ..	1,269	947	2,761	1,696	486	109	466	366	269	39	65	31
1948–49 ..	1,406	1,138	2,598	1,502	610	118	504	690	298	38	62	34

APPENDIX XV.

Area sown with crops.

Korra in 00 acres.

Year. (1)	Visakhapatnam. (2)	East Godavari. (3)	West Godavari. (4)	Kistna. (5)	Guntur. (6)	Kurnool. (7)	Bellary. (8)	Anantapur. (9)	Cuddapah. (10)	Nellore. (11)	Chingleput. (12)	South Arcot. (13)	Chittoor. (14)	North Arcot. (15)	Salem. (16)	Coimbatore. (17)	Tiruchirappalli. (18)	Tanjore. (19)	Madurai. (20)	Ramanathapuram. (21)	Tirunelveli. (22)	Malabar. (23)	South Kanara. (24)	The Nilgiris. (25)
1921–22 ..	198	107		86	856	3,949	4,227	2,671	846	131	3	127	53	12	193	197	8	1	110	8	3	..	..	..
1922–23 ..	155	65		53	888	3,799	3,598	1,764	733	127	6	143	47	11	177	186	7	1	88	7	2	..	..	1
1923–24 ..	214	72		62	949	4,332	5,726	2,655	745	143	5	93	49	15	169	198	8	1	100	10	2	..	..	2
1924–25 ..	183	81	34	46	837	4243	5,935	2,771	820	224	7	109	50	20	235	219	9	1	75	45	2	..	3	..
1925–26 ..	168	66	20	35	877	4,306	4,817	3,249	950	266	9	117	72	20	234	267	12	2	86	10	2	..	..	2
1926–27 ..	174	50	10	36	815	3,496	4,799	2,743	849	255	12	91	74	15	246	266	10	1	89	3	3	..	..	2
1927–28 ..	177	56	10	39	775	4,217	5,803	3,288	1,130	283	11	128	62	13	234	254	13	1	78	6	4	1	..	4
1928–29 ..	182	45	12	27	878	3,904	5,223	3,236	964	311	10	95	58	18	239	251	10	1	72	6	4	..	..	2
1929–30 ..	343	52	12	30	997	3,852	3,568	2,692	968	366	7	86	100	10	180	300	13	1	79	6	2	..	..	2
1930–31 ..	190	45	10	23	637	4,232	5,485	3,329	912	354	3	64	54	9	151	309	7	1	66	3	2	2	..	2
1931–32 ..	279	54	19	30	868	4,497	4,815	2,338	910	308	5	66	25	8	149	282	6	1	79	2	3	3	..	2
1932–33 ..	259	44	10	38	815	4,450	6,742	3,589	1,059	356	6	69	23	8	137	257	6	1	89	2	2	3	..	7
1933–34 ..	244	39	7	19	784	4,986	4,818	3,617	1,251	873	11	78	42	11	112	240	6	1	85	1	2	11	..	2
1934–35 ..	240	30	6	15	788	4,670	4,332	3,012	1,062	339	7	82	31	10	118	157	7	1	71	2	3	10	..	2
1935–36 ..	210	39	6	12	631	4,440	5,257	2,987	1,060	823	12	80	32	36	116	173	8	1	87	2	2	8	..	3
1936–37 ..	225	39	6	5	628	4,000	3,810	2,182	890	273	6	57	28	7	122	211	7	1	84	2	3	10	..	2
1937–38 ..	152	32	4	4	531	4,004	3,879	2,750	891	237	9	58	26	11	132	169	7	1	75	1	2	9	..	2
1938–39 ..	118	41	7	7	597	4,806	6,501	3,788	1,248	254	4	69	24	9	133	157	8	1	77	1	2	10	..	1
1939–40 ..	95	38	7	11	603	4,644	5,412	3,130	1,156	252	9	86	23	13	153	191	7	1	75	1	6	10	..	1
1940–41 ..	115	44	8	12	670	4,494	4,921	3,115	1,095	249	13	92	25	13	121	237	5	1	91	2	4	11	..	2
1941–42 ..	123	39	8	10	807	4,618	5,152	3,394	1,142	231	9	87	27	13	134	222	7	1	100	3	3	9	..	2
1942–43 ..	115	49	22	14	980	4,995	3,607	2,926	1,170	345	8	109	27	16	143	218	8	1	109	4	5	11	..	2
1943–44 ..	108	58	16	13	745	4,820	5,627	3,239	1,014	340	8	81	25	16	151	263	8	1	103	7	4	12	..	2
1944–45 ..	98	42	9	11	762	3,664	5,207	3,031	912	294	4	51	21	10	140	322	5	..	101	48	3	12	..	3
1945–46 ..	90	35	7	16	854	4,180	5,654	3,382	1,062	318	5	81	13	11	129	207	5	..	116	3	2	11	..	2
1946–47 ..	100	29	6	6	608	3,896	5,699	3,649	1,149	325	7	80	19	9	135	249	6	..	108	1	1	11	..	3
1947–48 ..	81	35	5	6	684	4,170	5,442	3,282	978	325	4	62	18	8	127	267	6	..	118	1	2	11	..	3
1948–49 ..	96	33	6	13	781	4,812	5,387	3,747	1,150	285	14	108	26	14	127	284	7	..	113	32	2	12	..	2

APPENDIX XVI.

Area sown with crops.

Veragu in 00 acres.

Year.	Visakhapatnam.	East Godavari.	West Godavari.	Kristna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921-22 ..	135	20		103	92	1,377	23	395	282	948	394	1,432	222	925	788	86	1,791	678	1,034	1,279	180	..	..	..
1922-23 ..	130	29		127	72	1,052	20	291	247	1,103	415	1,566	118	712	604	58	1,624	627	721	1,147	133	..	..	..
1923-24 ..	115	59		155	69	1,087	21	327	183	383	272	1,744	76	807	512	62	1,554	639	549	1,073	159	..	..	..
1924-25 ..	106	49	46	103	69	773	12	406	159	1,254	824	1,640	177	893	650	74	1,719	670	776	1,210	199	..	..	..
1925-26 ..	140	41	16	101	380	983	17	338	383	1,250	439	1,555	247	894	611	86	1,550	637	513	1,127	129	..	..	..
1926-27 ..	84	56	22	45	59	839	15	525	264	762	327	1,926	264	912	806	83	1,902	691	871	1,066	131	..	..	..
1927-28 ..	63	36	23	64	41	1.015	15	497	282	1,082	400	1,540	157	579	752	98	1,634	645	789	1,091	121	..	..	..
1928-29 ..	85	44	18	54	56	794	14	426	278	1,340	464	1,798	160	730	693	79	1,708	638	574	967	88	..	..	..
1929-30 ..	93	45	17	52	49	706	9	214	145	1,076	305	1,695	163	627	732	134	1,640	691	604	1,017	97	..	..	..
1930-31 ..	88	54	17	49	44	802	12	377	179	699	286	1,400	189	718	711	78	1,545	610	658	1,084	142	..	..	..
1931-32 ..	88	62	23	65	57	992	22	334	266	1,097	282	1,701	269	1,006	840	74	1,687	624	653	956	72	..	..	..
1932-33 ..	88	27	16	65	66	944	19	456	441	1,191	267	1,711	268	884	862	63	1,765	628	835	1,046	154	..	..	..
1933-34 ..	67	38	16	87	63	987	24	453	367	1,208	218	1,503	224	881	742	57	1,861	525	824	995	195	..	..	..
1934-35 ..	66	24	9	65	47	1,011	3	358	310	1,140	374	1,789	231	965	590	55	1,435	448	408	723	79	..	..	..
1935-36 ..	61	27	14	73	64	856	21	310	304	1487	336	1,674	177	911	672	57	1,561	382	541	881	82	1	..	..
1936-37 ..	77	19	9	47	41	751	19	454	208	767	266	1,296	208	601	644	65	1,488	418	498	948	93	1	..	2
1937-38 ..	65	16	7	40	41	889	18	391	255	797	326	1,479	142	614	688	43	1,596	367	526	955	86	1	..	..
1938-39 ..	103	21	8	39	13	951	16	302	368	1,232	301	1,484	173	555	725	44	1,575	354	720	952	81	1	..	6
1939-40 ..	97	27	9	37	39	948	9	344	233	851	290	1,524	103	427	597	69	1,368	357	551	842	70	1	..	..
1940-41 ..	81	28	11	34	25	847	4	249	303	894	402	1,731	156	699	666	57	1,490	349	331	864	58	2	..	..
1941-42 ..	71	31	18	86	371	754	3	276	268	936	495	2,136	105	1,016	762	47	1,726	419	647	843	83	1	..	..
1942-43 ..	96	37	27	42	486	961	13	312	308	1,368	294	1,623	207	975	754	52	1,467	356	790	878	72	1	..	..
1943-44 ..	94	30	22	31	42	826	6	306	256	1,428	333	1,411	183	644	658	59	1,406	320	609	731	113	..	..	
1944-45 ..	103	26	14	23	46	1,009	8	516	408	955	170	1,009	179	415	716	93	1,818	276	632	912	139	3	..	..
1945-46 ..	83	25	9	32	139	986	11	380	386	1,027	170	1,487	160	571	714	69	1,402	296	521	697	76	..	..	..
1946-47 ..	101	18	40	24	234	696	5	328	275	1,095	207	1,193	112	406	667	77	1,248	258	459	509	43	..	..	..
1947-48 ..	81	29	14	31	252	1,118	13	490	307	903	180	1,271	156	510	782	126	1,401	259	615	310	39	..	..	..
1948-49 ..	104	18	15	27	50	1,162	3	395	316	1,557	242	1,123	104	380	598	104	1,689	238	518	682	54	..	.	..

APPENDIX XVII.

Area sown with crops.

Samai in 00 acres.

Year.	Vizakhapatnam.	East Godavari.	West Godavari.	Kistna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921-22 ..	230	85		20	..	8	181	886	24	20	..	21	109	320	1,331	944	177	1	884	197	773	159	2	29
1922-23 ..	139	67		20	..	13	137	605	18	6	1	25	90	275	1,119	841	209	1	828	181	674	191	2	30
1923-24 ..	1,251	100		29	..	23	168	809	25	20	1	48	128	351	1,161	696	322	2	774	136	569	179	2	40
1924-25 ..	1,359	117	28	3	..	14	134	617	27	30	1	36	171	464	1,341	742	214	3	533	161	506	180	2	44
1925-26 ..	1,320	85	14	..	..	108	151	1,155	27	23	1	57	144	418	1,311	728	187	3	810	144	437	170	2	42
1926-27 ..	1,476	75	14	..	..	148	176	1,074	30	17	..	29	133	395	1,495	851	290	6	1,205	151	394	171	2	40
1927-28 ..	1,486	93	17	..	..	7	235	1,178	24	51	1	23	156	377	1,260	788	243	3	1,024	161	373	176	2	41
1928-29 ..	1,457	90	18	..	..	12	198	1,141	26	35	1	39	182	393	1,379	650	290	7	1,167	158	400	155	2	34
1929-30 ..	1,737	95	16	..	..	8	127	918	40	52	1	33	308	365	1,374	744	360	9	1,365	178	603	206	2	35
1930-31 ..	1,659	96	16	..	..	8	161	936	45	42	1	19	189	320	1,238	740	258	5	1,100	167	609	178	2	27
1931-32 ..	1,510	112	21	1	..	10	132	677	44	37	1	21	149	383	1,421	793	316	4	904	121	469	178	2	25
1932-33 ..	1,497	88	15	..	..	10	170	1,027	66	17	..	20	163	311	1,317	853	256	3	954	186	485	160	2	33
1933-34 ..	1,500	87	10	..	..	12	123	1,162	66	16	1	17	156	284	1,184	791	254	2	750	109	485	139	2	38
1934-35 ..	1,487	80	11	..	10	7	127	838	38	13	1	24	146	297	1,092	629	248	2	770	112	400	119	2	38
1935-36 ..	198	92	9	..	..	10	98	478	45	17	1	24	155	306	1,293	652	214	2	690	116	422	111	2	42
1936-37 ..	289	84	8	1	1	8	100	544	31	18	1	14	150	318	1,362	776	213	2	911	125	457	119	2	42
1937-38 ..	247	76	6	1	..	8	90	558	50	31	1	17	114	254	1,240	657	227	2	859	112	470	122	2	44
1938-39 ..	277	92	9	..	9	4	169	851	43	17	1	15	140	267	1,418	674	212	1	642	108	369	122	2	48
1939-40 ..	290	93	10	..	9	6	168	640	31	18	2	16	138	288	1,342	637	142	1	756	137	475	120	2	51
1940-41 ..	228	85	8	..	2	9	116	703	37	14	2	19	142	297	1,186	622	168	1	1,005	137	464	121	2	52
1941-42 ..	296	78	6	1	..	14	158	1,107	53	31	2	27	167	311	1,377	708	245	1	1,344	141	541	127	2	52
1942-43 ..	354	59	46	..	18	5	118	662	42	11	2	31	178	320	1,353	615	192	2	921	187	561	126	2	49
1943-44 ..	344	58	41	..	..	9	74	528	40	30	1	20	158	329	1,323	705	182	1	843	126	594	118	2	65
1944-45 ..	329	58	30	..	2	4	74	547	26	19	..	20	118	251	1,391	815	136	1	948	124	500	86	2	63
1945-46 ..	278	45	33	..	6	5	87	763	25	12	..	11	107	264	1,425	589	126	..	622	97	348	76	2	54
1946-47 ..	192	48	34	..	..	6	81	668	29	18	..	21	126	243	1,379	599	195	..	582	80	262	73	2	48
1947-48 ..	176	53	36	..	3	7	86	651	66	26	1	18	138	280	1,445	577	118	..	395	86	172	58	2	44
1948-49 ..	189	50	33	..	..	9	63	934	29	63	1	24	101	263	1,254	577	138	..	399	30	147	54	2	42

APPENDIX XVIII.

Area sown with crops.

Maize in 00 acres.

Year.	Visakhapatnam.	East Godavari.	West Godavari.	Kristna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22 ..	13	3		245	368	1	1	2	2	1	..	..	..	10	8	..	1	4	8	2	..	..	..	..
1922–23 ..	12	9		256	532	1	2	2	..	1	..	..	1	8	63	..	35	2	..	2	..	1	..	..
1923–24 ..	148	40		279	581	..	2	12	..	2	..	..	..	7	45	..	71	2	..	2	..	1	..	..
1924–25 ..	149	55	14	237	608	1	..	1	1	29	..	..	1	17	150	..	102	7	6	17	..	1	..	..
1925–26 ..	151	38	13	264	624	5	..	1	..	1	..	3	1	22	90	1	112	3	14	5	1	1	..	..
1926–27 ..	150	37	13	253	323	2	1	2	..	1	..	..	..	19	83	..	92	4	46	12	..	..	..	..
1927–28 ..	70	33	14	246	754	1	1	3	..	4	..	..	..	16	238	1	131	8	10	18	..	..	..	..
1928–29 ..	158	36	14	212	493	1	..	1	..	1	..	..	3	8	72	1	67	7	10	10	22	..	..	..
1929–30 .	160	35	19	248	445	1	1	2	2	1	..	..	..	14	59	3	29	6	24	10	20	..	..	..
1930–31 ..	163	36	16	250	784	..	1	..	1	1	..	..	1	27	47	3	73	4	4	1	..	2	..	..
1931–32 ..	155	43	18	203	504	1	4	2	1	..	..	..	1	19	46	6	5	3	1	7	1	1	..	..
1932–33 ..	155	42	15	190	444	3	1	1	..	..	..	..	..	13	48	6	8	2	..	1	3	..	..	..
1933–34 ..	158	42	17	161	457	2	1	2	..	87	..	..	..	21	19	3	11	1	..	8	7	..	..	..
1934–35 ..	156	54	16	114	214	1	3	4	1	1	1	1	..	7	11	2	12	4	8	10	..	..	..	..
1935–36 ..	23	39	12	140	379	1	2	3	2	2	..	2		5	6	10	27	6	17	13	..	..	..	..
1936–37 ..	20	42	14	138	445	1	1	2	..	1	1	1	..	6	6	3	33	34	8	47	3	..	..	..
1937–38 ..	136	44	14	124	215	1	2	1	..	1	1	1	1	7	7	2	18	9	137	..	..	..	..	.
1938–39 ..	111	45	14	118	286	1	1	1	..	3	..	10	1	7	10	1	18	5	9	1	..	.	..	..
1939–40 ..	106	41	12	87	326	8	1	1	2	3	..	11	..	6	9	1	13	110	8	5	1	..	..	.
1940–41 ..	82	42	12	99	275	1	..	..	..	3	1	15	..	6	8	2	18	111	4	1	..	..	..	..
1941–42 ..	86	33	12	90	267	16	1	1	2	1	..	2	..	6	9	3	13	109	5	1	..	..	..	..
1942–43 ..	19	32	18	108	258	1	2	2	2	7	..	1	1	8	14	2	15	105	4	..	..	..	..	..
1943–44 ..	19	41	17	91	249	2	11	1	..	..	..	2	..	6	7	2	25	96	60	..	..	1	..	..
1944–45 ..	18	37	15	75	229	1	2	..	..	1	..	1	3	6	6	1	14	77	31	..	..	1	..	..
1945–46 ..	33	36	18	64	126	4	1	..	..	3	..	1	..	5	10	5	16	63	4	1	..	1	..	..
1946–47 ..	26	34	20	60	220	..	2	2	2	..	..	2	..	6	11	4	15	73	2	1	1	1	..	..
1947–48 ..	33	34	12	64	215	8	2	..	..	1	..	2	..	6	9	1	16	60	1	..	..	1	..	..
1948–49 ..	33	34	12	63	272	148	1	1	..	1	..	3	..	6	6	2	29	54	5	..	..	1	..	..

APPENDIX XIX.

Area sown with crops.

Other cereals in 00 acres.

ear. (1)		Visakhapatnam. (2)	East Godavari. (3)	West Godavari. (4)	Krishna. (5)	Guntur. (6)	Kurnool. (7)	Bellary. (8)	Anantapur. (9)	Cuddapah. (10)	Nellore. (11)	Chingleput. (12)	South Arcot. (13)	Chittoor. (14)	North Arcot. (15)	Salem. (16)	Coimbatore. (17)	Tiruchirappalli. (18)	Tanjore. (19)	Madurai. (20)	Ramanathapuram. (21)	Tirunelveli. (22)	Malabar. (23)	South Kanara. (24)	The Nilgiris. (25)
1921-22	..	564	76		123	3,558	298	122	50	162	144	..	7	7	44	209	9	75	1	333	671	316	..	..	165
1922-23	..	567	65		114	3,373	282	173	58	95	5	..	15	9	53	133	26	7	5	357	692	338	..	..	102
1923-24	..	853	124		81	3,920	241	95	41	195	127	1	14	23	44	137	11	11	20	385	655	309	..		91
1924-25	..	778	89	59	26	3,422	240	55	31	127	26	7	7	8	45	176	12	19	5	250	784	310	..	..	95
1925-26	..	851	76	33	20	3,447	30	89	62	125	27	1	13	7	59	138	17	15	4	363	696	349	..	..	93
1926-27	..	746	89	..	72	2,597	239	69	24	129	413	5	66	4	17	149	7	19	4	407	782	406	..	..	92
1927-28	..	564	48	..	5	2,912	200	80	22	139	152	2	17	2	18	193	21	24	2	297	626	360	..	..	90
1928-29	..	556	25	1	21	3,029	285	74	19	65	40	..	25	5	8	148	7	24	9	448	722	357	..	..	86
1929-30	..	806	30	15	8	3,449	399	100	22	132	205	8	20	5	39	101	8	19	11	378	852	404	..	..	79
1930-31	..	640	17	8	19	3,036	311	103	18	150	303	1	13	3	43	94	10	11	1	305	734	383	..	..	86
1931-32	..	591	1	12	5	3,093	262	81	58	122	427	5	24	5	35	72	13	6	3	270	762	378	..	..	87
1932-33	..	428	1	6	11	2,856	228	60	56	188	370	10	21	7	20	81	9	8	3	223	731	310	..	..	59
1933-34	..	431	30	5	9	3,236	255	80	25	162	345	4	10	3	35	85	10	5	3	195	543	319	..	..	64
1934-35	..	407	89	6	27	3,024	295	185	29	222	171	..	9	7	32	84	7	6	3	157	480	292	..	..	66
1935-36	..	887	63	7	8	3,249	209	58	51	108	197	2	6	3	35	76	10	10	5	270	515	175	11	..	61
1936-37	..	858	82	18	15	2,885	241	53	32	123	246	1	8	3	19	103	14	16	5	420	800	381	..	..	61
1937-38	..	586	31	6	21	2,685	66	89	20	147	343	3	5	6	26	94	9	7	4	323	786	279	2	..	62
1938-39	..	379	39	4	24	2,435	96	61	118	110	267	1	5	2	30	66	7	7	2	243	720	268	3	..	48
1939-40	..	325	28	7	7	2,695	187	91	126	181	279	4	3	2	15	105	7	9	2	300	780	364	5	..	49
1940-41	..	868	24	4	8	2,625	246	97	18	83	270	3	5	1	21	116	9	5	4	337	798	375	6	..	51
1941-42	..	375	42	12	12	3,068	414	126	20	109	321	2	2	4	24	88	10	7	3	382	742	322	16	..	38
1942-43	..	833	42	4	8	2,525	187	90	31	112	149	1	17	5	36	87	15	8	2	308	882	409	5	..	38
1943-44	..	427	42	3	7	2,827	260	93	27	77	97	2	1	4	17	99	14	6	2	328	693	869	4	..	10
1944-45	..	326	24	4	6	2,854	240	74	17	71	334	1	1	2	9	69	18	4	2	275	694	446	8	..	12
1945-46	..	310	39	3	7	2,720	230	76	21	97	97	1	1	5	13	73	24	5	1	231	587	401	22	..	20
1946-47	..	410	50	..	4	2,278	208	79	17	87	125	1	3	1	16	56	20	17	3	283	644	360	12	..	23
1947-48	..	480	27	1	7	2,684	29	58	15	120	124	2	1	4	14	45	18	5	1	232	405	247	12	..	22
1948-49	..	328	25	4	5	2,888	39	151	42	111	5	3	..	4	27	68	14	13	2	309	466	403	2	..	23

APPENDIX XX.

Area sown with crops.

Greengram in 00 acres.

Year.	Vizakhapatnam.	East Godavari.	West Godavari.	Kristna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22 ..	545	347		296	130	44	182	28	10	179	6	2	9	17	81	80	18	7	11	57	152	15	72	..
1922–23 ..	578	295		333	118	30	116	8	8	266	6	4	8	14	125	82	12	5	10	53	104	28	86	..
1923–24 ..	655	276		270	99	28	134	15	6	179	4	3	7	19	93	51	5	4	15	48	110	18	78	..
1924–25 ..	592	330	36	304	111	33	131	11	6	196	4	7	4	19	77	67	10	231	8	53	121	17	75	..
1925–26 ..	695	417	27	248	113	27	105	9	4	163	5	10	7	15	92	60	9	6	7	32	126	20	80	..
1926–27 ..	582	489	25	254	121	36	162	18	9	185	4	5	7	11	81	52	11	5	5	19	105	47	81	..
1927–28 ..	695	478	23	314	132	39	143	18	5	187	7	6	6	14	111	62	12	18	7	15	122	35	83	..
1928–29 ..	686	455	35	294	103	39	156	19	7	198	26	9	7	14	80	68	16	101	8	17	144	23	83	..
1929–30 ..	724	482	32	304	106	61	101	19	6	215	10	7	8	20	75	74	13	604	5	25	108	30	79	..
1930–31 ..	827	415	31	280	139	45	168	24	16	223	5	6	8	13	71	76	18	821	13	28	124	32	81	..
1931–32 ..	798	461	33	313	109	41	196	19	11	206	4	8	3	15	78	70	8	825	11	31	137	23	83	..
1932–33 ..	864	507	32	294	114	36	200	40	5	223	4	10	3	20	91	91	14	787	16	31	135	24	79	..
1933–34 ..	910	522	34	237	106	41	153	25	5	236	8	12	3	17	95	80	15	478	6	28	132	24	79	..
1934–35 ..	885	510	32	202	120	50	206	33	5	240	7	14	10	28	95	68	19	437	7	34	129	21	79	..
1935–36 ..	1,295	562	30	211	135	53	219	48	7	244	6	19	6	41	91	82	15	550	10	33	136	22	82	..
1936–37 ..	1,564	584	25	171	144	58	187	49	4	269	5	23	6	34	107	81	20	585	9	35	169	22	85	..
1937–38 ..	1,356	556	25	187	148	52	151	46	5	241	4	20	4	23	94	97	25	474	13	43	164	25	85	..
1938–39 ..	1,644	537	23	244	173	75	171	50	12	265	4	30	3	28	85	103	15	446	5	38	141	26	84	..
1939–40 ..	1,267	492	28	247	208	70	184	83	13	245	6	21	4	36	102	125	16	463	10	37	132	20	83	..
1940–41 ..	1,399	536	20	269	190	69	176	45	42	228	5	24	5	33	90	123	14	507	10	45	131	28	84	..
1941–42 ..	1,568	518	26	252	187	75	200	48	46	231	4	25	5	41	93	185	14	447	11	38	153	25	82	..
1942–43 ..	1,581	585	33	253	302	77	215	72	43	245	13	274	4	39	101	148	25	818	11	47	155	19	79	..
1943–44 ..	1,438	522	26	464	428	79	203	61	43	226	3	208	2	28	88	140	24	802	14	47	214	23	89	..
1944–45 ..	1,267	515	26	451	336	57	188	65	31	200	2	167	5	26	80	129	56	996	12	37	180	14	79	..
1945–46 ..	1,343	474	30	386	240	53	203	60	49	215	5	70	9	29	70	121	35	756	15	9	221	15	80	..
1946–47 ..	1,294	483	27	467	289	63	212	79	39	218	3	79	5	30	75	126	38	870	10	30	191	18	81	..
1947–48 ..	1,105	396	25	504	693	60	202	74	46	226	18	114	5	38	70	109	21	707	10	8	85	16	83	..
1948–49 ..	1,085	435	30	326	704	102	192	67	51	209	9	56	6	32	76	129	52	764	10	13	68	23	85	..

APPENDIX XXI.

Area sown with crops.

Redgram in 00 acres.

Year. (1)		Vizakhapatnam. (2)	East Godavari. (3)	West Godavari. (4)	Kistna. (5)	Guntur. (6)	Kurnool. (7)	Bellary. (8)	Anantapur. (9)	Cuddapah. (10)	Nellore. (11)	Chingleput. (12)
1921–22	..	90	63		91	252	185	367	154	4	33	4
1922–23	..	78	62		89	235	161	289	98	3	45	4
1923–24	..	198	77		81	194	145	305	122	2	35	2
1924–25	..	254	84	55	41	209	173	309	139	3	16	3
1925–26	..	194	65	37	30	202	123	228	101	1	16	7
1926–27	..	194	58	42	37	239	168	325	162	3	27	2
1927–28	..	279	75	49	50	248	239	305	179	2	20	4
1928–29	..	272	84	45	52	190	136	271	140	2	13	3
1929–30	..	285	91	58	43	212	96	234	120	3	12	3
1930–31	..	293	80	66	40	236	200	309	161	5	17	2
1931–32	..	218	78	51	54	218	216	313	153	3	13	2
1932–33	..	219	73	58	52	218	227	310	227	4	20	2
1933–34	..	209	77	63	54	229	261	260	236	4	24	2
1934–35	..	229	87	62	47	231	278	279	277	3	25	2
1935–36	..	156	83	68	61	219	309	348	345	35	21	3
1936–37	..	145	95	58	65	232	265	300	355	41	18	3
1937–38	..	191	78	62	47	199	257	272	330	26	15	2
1938–39	..	178	97	67	58	224	360	350	453	39	23	2
1939–40	..	169	98	61	51	211	308	300	432	37	21	4
1940–41	..	190	94	62	58	216	316	305	367	42	21	4
1941–42	..	159	95	60	45	189	301	299	363	44	22	3
1942–43	..	166	85	67	50	210	407	371	479	49	29	6
1943–44	..	178	107	88	55	234	421	365	472	74	32	3
1944–45	..	141	120	74	63	211	341	304	494	69	26	4
1945–46	..	196	102	75	61	219	368	325	528	77	41	3
1946–47	..	148	110	66	65	218	370	383	606	85	49	4
1947–48	..	147	96	57	68	257	385	345	494	100	48	2
1948–49	..	187	102	78	55	259	428	312	556	84	43	4

Year. (1)	South Arcot. (13)	Chittoor. (14)	North Arcot. (15)	Salem. (16)	Coimbatore. (17)	Tiruchirappalli. (18)	Tanjore. (19)	Madurai. (20)	Ramanathapuram. (21)	Tirunelveli. (22)	Malabar. (23)	South Kanara. (24)	The Nilgiris. (25)
1921–22	41	20	202	198	130	291	87	71	51	20	20	..	..
1922–23	50	20	262	179	120	210	93	67	58	16	17	..	..
1923–24	23	17	103	152	81	34	68	26	43	38	19	..	..
1924–25	50	16	205	196	150	216	77	88	123	51	15	..	..
1925–26	40	22	191	162	113	270	91	69	28	25	16	..	..
1926–27	22	15	127	172	87	166	72	32	28	42	13	..	..
1927–28	53	16	159	191	114	225	75	63	64	51	13	..	..
1928–29	39	17	192	184	128	258	95	38	27	20	26	..	..
1929–30	43	16	191	120	109	202	80	46	40	50	19	..	..
1930–31	43	14	200	123	160	350	69	68	35	73	42	..	..
1931–32	58	16	206	148	108	115	83	89	15	24	17	..	..
1932–33	78	16	220	154	148	403	90	82	41	68	14	..	..
1933–34	78	17	210	125	152	296	85	61	79	94	13	..	..
1934–35	65	70	231	119	93	268	55	12	38	82	46	..	..
1935–36	59	55	275	136	91	415	68	39	48	19	30	..	..
1936–37	81	41	27[illegible]	156	133	249	74	57	80	90	88	..	..
1937–38	79	30	295	161	123	317	61	38	39	27	21	..	..
1938–39	81	26	320	165	98	278	62	42	63	58	29	..	..
1939–40	93	32	302	194	126	435	65	50	15	24	35	..	..
1940–41	116	43	391	177	176	423	57	59	92	93	34	..	..
1941–42	81	28	233	143	139	325	51	39	28	17	35	..	..
1942–43	101	30	289	171	149	449	65	51	69	53	53	..	..
1943–44	106	31	327	167	138	374	60	51	21	26	62	..	..
1944–45	126	43	319	174	96	431	64	47	58	42	67	9	..
1945–46	113	57	354	163	107	305	62	46	46	39	71	..	..
1946–47	186	56	387	167	117	340	74	41	70	61	78	..	..
1947–48	110	53	343	140	123	381	61	68	82	46	22	..	..
1948–49	111	52	388	163	152	437	64	63	44	35	23	..	..

APPENDIX XXII.

Area sown with crops.

Blackgram in 00 acres.

Year.	Visakhapatnam.	East Godavari.	West Godavari.	Kistna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22 ..	122	229		118	10	41	..	..	2	27	29	26	8	73	149	134	13	26	99	137	204	51	107	..
1922–23 ..	117	246		96	11	38	..	..	2	67	37	32	7	67	104	114	11	28	92	133	174	51	129	..
1923–24 ..	166	231		112	8	24	1	..	4	12	35	20	8	91	81	114	20	19	91	150	205	51	110	..
1924–25 ..	171	285	35	131	7	19	1	..	1	12	36	31	2	52	68	100	16	35	74	59	195	43	116	..
1925–26 ..	169	294	36	98	4	43	..	1	1	13	40..	21	7	50	73	82	11	26	59	72	165	47	120	..
1926–27 ..	218	303	27	82	4	29	..	..	2	16	38	23	6	51	78	62	13	38	52	78	186	48	115	..
1927–28 ..	262	376	28	112	12	19	..	..	2	18	31	13	6	42	78	70	11	37	48	65	170	52	120	..
1928–29 ..	243	387	33	112	8	21	..	..	1	43	28	11	6	28	73	72	13	50	46	72	173	56	113	..
1929–30 ..	253	383	33	114	8	31	..	..	4	18	30	14	6	50	67	62	15	111	69	80	201	61	104	..
1930–31 ..	273	340	20	115	11	36	..	..	1	23	32	15	5	39	72	82	19	90	109	82	256	55	111	..
1931–32 ..	183	353	33	151	17	35	1	..	2	22	40	16	4	46	86	80	18	96	121	92	256	52	117	..
1932–33 ..	200	353	58	151	28	29	1	..	1	21	46	17	3	70	146	108	18	112	161	115	307	52	115	5
1933–34 ..	186	320	43	142	24	37	..	..	3	23	55	21	4	78	133	83	19	93	141	137	314	55	112	..
1934–35 ..	186	354	33	117	33	24	..	1	4	16	37	23	4	75	125	88	33	99	152	135	290	49	112	..
1935–36 ..	157	340	27	95	53	25	6	1	1	14	38	21	5	60	79	84	16	97	142	99	276	52	111	..
1936–37 ..	161	373	32	124	73	27	1	1	1	13	34	18	3	55	94	64	13	121	120	100	273	61	121	..
1937–38 ..	249	359	21	120	108	32	2	..	1	11	36	35	3	38	112	71	15	114	129	105	289	55	121	..
1938–39 ..	226	335	21	119	188	38	55	..	1	12	27	20	1	34	69	57	17	113	92	97	269	47	118	..
1939–40 ..	239	376	24	125	150	29	2	..	1	11	53	22	4	53	67	54	14	116	94	87	236	41	125	..
1940–41 ..	221	372	25	162	106	22	1	6	1	10	47	22	7	45	81	70	19	111	87	69	273	42	116	..
1941–42 ..	255	406	26	139	113	28	2	..	1	14	61	45	7	61	98	110	24	111	135	92	248	63	111	..
1942–43 ..	229	376	35	143	301	36	2	..	3	26	147	163	6	78	125	133	37	196	175	110	279	63	111	..
1943–44 ..	261	427	35	387	350	45	8	3	1	20	31	153	23	45	77	111	31	206	137	96	283	63	126	..
1944–45 ..	249	413	24	349	332	37	1	..	3	20	53	198	5	47	77	94	51	318	140	126	350	61	121	..
1945–46 ..	256	398	32	355	267	27	4	1	4	20	64	104	8	66	103	151	61	280	207	138	355	58	121	..
1946–47 ..	244	372	29	380	306	13	8	..	1	17	54	126	4	68	95	118	62	310	189	138	329	69	124	..
1947–48 ..	180	339	29	265	428	28	2	..	1	18	63	157	3	63	94	117	51	311	201	118	235	82	122	..
1948–49 ..	207	326	26	358	360	40	6	1	1	14	69	103	5	48	93	102	105	335	174	96	268	85	122	..

APPENDIX XXIII.

Area sown with crops.

Bengalgram in 00 acres.

Year. (1)	Vizakhapatnam. (2)	East Godavari. (3)	West Godavari. (4)	Krishna. (5)	Guntur. (6)	Kurnool. (7)	Bellary. (8)	Anantapur. (9)	Cuddapah. (10)	Nellore. (11)	Chingleput. (12)	South Arcot. (13)	Chittoor. (14)	North Arcot. (15)	Salem. (16)	Coimbatore. (47)	Tiruchirappalli. (18)	Tanjore. (19)	Madurai. (20)	Ramanathapuram. (21)	Tirunelveli. (22)	Malabar. (23)	South Kanara. (24)	The Nilgiris. (25)
1921–22	11	49		100	145	193	210	96	14	109	..	7	2	10	25	58	2	3	11	42	15	1	..	..
1922–23	18	54		106	195	279	236	152	25	11	1	1	3	2	21	42	4	..	5	53	15	1	..	..
1923–24	22	180		213	208	126	66	80	14	9	1	2	1	3	19	26	4	..	6	47	16	..	..	..
1924–25	23	130	70	136	217	111	118	82	17	14	..	1	2	5	28	36	3	..	8	65	17	1	..	1
1925–26	15	86	78	122	209	131	198	104	24	18	..	3	1	5	30	30	2	..	3	79	14	1	..	..
1926–27	17	34	16	23	80	117	112	71	10	15	..	..	..	2	12	23	1	..	2	27	9	..	..	..
1927–28	24	50	14	62	135	123	129	60	12	6	..	..	..	1	13	42	4	..	3	14	11	..	..	..
1928–29	23	70	37	60	141	111	110	52	8	5	..	..	1	1	27	35	2	..	9	19	9	..	..	1
1929–30	26	67	25	31	67	122	193	73	12	9	2	..	1	1	11	69	2	..	3	10	11	1	..	..
1930–31	36	67	41	56	123	177	135	53	27	11	1	1	1	1	15	55	8	..	3	10	11	4	..	..
1931–32	33	94	98	76	135	200	152	103	41	9	1	12	1	4	15	54	3	..	3	4	10	..	..	..
1932–33	34	58	38	71	169	188	151	56	24	13	..	2	1	1	18	51	2	..	3	4	10	..	..	..
1933–34	32	65	70	92	246	155	175	61	18	9	2	2	..	1	8	50	4	..	2	4	12	..	..	..
1934–35	37	50	21	63	13	208	328	189	37	7	3	8	1	1	12	53	2	..	3	4	12	1	..	..
1935–36	46	62	36	49	105	152	121	47	15	7	1	1	..	2	13	51	4	1	4	4	11	14	..	..
1936–37	21	47	34	48	119	188	206	94	19	5	2	2	..	1	10	45	2	1	2	9	7	21	..	..
1937–38	20	38	16	36	40	73	123	68	9	6	..	..	..	5	14	36	2	..	2	9	8	16	..	..
1938–39	19	45	31	32	54	78	85	65	17	13	..	1	..	4	7	18	3	1	6	10	7	15	..	..
1939–40	16	79	41	42	77	108	127	81	15	9	1	1	..	1	9	22	3	..	1	1	6	14	..	..
1940–41	27	49	31	37	100	148	118	64	16	9	2	..	..	4	9	28	2	..	3	1	5	12	..	..
1941–42	18	44	15	29	73	176	86	67	16	6	..	1	..	3	6	20	1	..	2	3	4	12	..	..
1942–43	5	42	22	29	85	170	48	75	13	6	2	1	1	2	6	31	4	..	2	6	4	3	..	..
1943–44	58	49	26	34	73	154	97	77	23	8	1	2	1	..	8	33	2	..	1	..	5	..	..	..
1944–45	14	46	38	30	72	241	169	106	42	3	1	1	..	1	5	28	1	..	1	1	4	2	..	..
1945–46	5	36	38	29	88	225	66	69	51	3	..	..	..	..	5	25	1	..	2	2	5	..	..	..
1946–47	8	62	28	44	108	345	186	110	92	5	1	..	..	..	13	30	1	..	5	2	3	1	..	..
1947–48	5	61	41	35	88	173	121	125	51	4	..	1	..	..	3	34	..	..	..	..	5	..	..	..
1948–49	9	58	38	40	84	373	160	158	49	3	..	1	1	1	9	34	1	..	5	2	4	..	..	..

APPENDIX XXIV.

Area sown with crops.

Horsegram in 00 acres.

Year. (1)	Visakhapatnam. (2)	East Godavari. (3)	West Godavari. (4)	Kistna. (5)	Guntur. (6)	Kurnool. (7)	Bellary. (8)	Anantapur. (9)	Cuddapah. (10)	Nellore. (11)	Chingleput. (12)	South Arcot. (13)	Chittoor. (14)	North Arcot. (15)	Salem. (16)	Coimbatore. (17)	Tiruchirappalli. (18)	Tanjore. (19)	Madurai. (20)	Ramanathapuram. (21)	Tirunelveli. (22)	Malabar. (23)	South Kanara. (24)	The Nilgiris. (25)
1921–22	725	479		819	557	641	660	2,509	615	696	37	68	400	414	2,144	2,249	290	17	895	149	859	66	219	..
1922–23 ..	992	522		857	560	927	843	2,700	410	1,032	51	82	380	540	2,420	2,236	437	20	1,360	143	783	60	235	..
1923–24 ..	1,123	648		894	523	587	788	1,623	524	815	73	106	559	636	1,840	2,003	493	19	1,242	140	819	63	222	..
1924–25 ..	919	632	501	497	467	727	712	2,260	555	871	92	107	675	662	2,137	1,604	387	22	941	134	778	65	219	..
1925–26 ..	899	731	544	518	481	822	1,023	3,192	578	834	86	115	631	633	2,250	2,065	427	23	1,186	148	632	65	230	..
1926–27 ..	891	676	356	266	148	806	826	3,483	596	760	75	80	529	540	2,360	2,225	357	20	947	107	511	61	218	..
1927–28 ..	875	731	437	383	417	707	724	2,762	471	713	80	60	466	542	2,123	1,889	248	21	691	101	573	63	232	..
1928 29 ..	897	805	516	438	404	778	807	2,911	482	945	107	84	556	492	2,220	2,168	415	24	1,101	103	625	61	237	..
1929–30 ..	896	765	533	354	385	783	1,390	1,577	784	1,151	163	101	800	697	2,227	2,263	545	21	1,218	141	701	63	198	..
1930–31 ..	990	166	480	352	504	857	1,086	3,416	651	1,254	76	86	596	540	2,157	2,260	418	13	1,086	158	805	67	226	..
1931–32 ..	1,098	678	473	389	468	876	941	3,110	605	1,132	65	51	440	476	2,224	2,105	418	11	835	191	755	59	245	..
1932–33 ..	1,177	732	474	364	466	754	997	3,178	472	1,192	78	85	488	514	2,278	1,942	322	8	636	163	674	55	235	..
1933–34 ..	1,131	762	486	397	479	824	888	2,535	433	1,173	78	51	410	492	2,134	1,930	336	9	603	144	612	41	238	..
1934–35 ..	1,118	791	522	357	431	939	707	1,266	482	1,231	59	64	421	609	2,710	2,175	531	9	836	140	566	29	236	..
1935–36 ..	1,059	783	514	386	342	695	969	2,519	397	1,246	94	63	458	585	2,188	2,046	287	9	692	150	590	32	231	..
1936–37 ..	1,334	828	450	299	400	728	1,002	2,828	413	1,205	107	79	577	612	2,406	1,989	346	5	886	135	680	38	244	..
1937–38 ..	1,358	79'	357	223	296	599	856	2,810	503	1,055	98	54	495	492	2,322	1,878	307	5	828	149	725	31	235	..
1938–39 ..	1,389	790	442	217	201	405	864	2,315	367	811	35	13	421	223	1,309	993	123	5	410	127	443	34	232	..
1939–40 ..	1,318	815	476	279	345	633	1,049	2,224	378	968	90	41	416	440	2,053	1,702	210	7	646	134	552	31	229	..
1940–41 ..	1,449	793	441	351	335	643	990	2,595	467	976	92	49	407	451	2,192	1,713	243	6	691	123	488	36	224	..
1941–42 ..	1,404	822	490	353	302	739	1,082	2,964	544	927	82	65	629	628	2,277	1,792	246	6	732	134	546	40	224	..
1942–43 ..	1,294	662	478	216	264	621	704	1,757	502	1,063	85	50	402	399	1,989	1,887	248	22	764	165	625	38	234	..
1943–44 ..	1,118	662	515	241	345	844	715	2,682	608	1,182	91	56	480	468	2,240	2,134	263	7	800	160	674	29	236	..
1944–45 ..	1,148	697	437	240	307	930	854	2,322	580	1,072	53	62	377	404	2,165	1,933	165	12	649	482	715	23	225	..
1945–46 ..	1,167	660	513	236	288	596	836	1,550	376	820	39	83	278	317	2,074	1,874	178	10	607	127	596	26	234	..
1946–47 ..	1,471	666	528	237	302	678	838	2,175	435	775	29	52	331	347	2,138	1,628	180	6	599	119	634	28	236	..
1947–48 ..	1,334	669	545	324	351	695	986	2,522	399	850	30	34	218	229	1,652	1,659	108	5	498	85	254	25	218	..
1948–49 ..	1,328	691	641	354	314	968	908	2,271	453	1,065	54	58	223	291	2,022	1,599	206	6	526	84	219	19	215	..

APPENDIX XXV.

Area sown with crops.

Other pulses in 00 acres.

Year.		Visakhapatnam.	East Godavari.	West Godavari.	Kistna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1921-22	..	285	77		84	8	22	215	24	106	11	8	15
1922-23	..	315	88		53	8	26	132	28	23	8	10	21
1223-24	..	108	101		62	9	34	137	27	6	17	6	17
1924-25	..	149	96	53	18	8	31	142	33	15	36	12	45
1925-26	..	113	86	91	12	12	10	127	29	23	23	18	48
1926-27	..	186	67	41	24	9	42	189	30	6	22	7	21
1927-28	..	107	89	47	33	11	20	159	37	19	12	8	9
1928-29	..	92	71	53	31	12	40	170	23	5	18	14	13
1929-30	..	120	73	42	12	16	34	130	16	30	11	10	17
1930-31	..	131	71	44	10	31	30	186	25	2	51	9	23
1931-32	..	117	67	44	27	14	22	195	30	8	31	8	72
1932-33		121	71	54	14	12	23	202	30	6	15	9	34
1933-34	..	121	53	71	17	19	16	157	31	4	25	7	19
1934-35	..	109	53	44	17	14	10	179	79	5	5	7	26
1935-36	..	131	61	55	11	13	10	211	35	23	10	10	13
1936-37	..	188	50	51	8	17	16	156	44	7	23	8	26
1937-38	..	137	49	33	8	47	13	168	41	7	13	4	15
1938-39	..	99	51	56	12	31	16	224	38	7	8	4	22
1939-40	..	99	48	58	7	12	11	198	59	6	6	3	19
1940-41	..	96	58	28	7	11	12	192	34	3	6	4	22
1941-42	..	114	48	40	13	10	12	225	36	6	10	3	22
1942-43	..	99	41	52	7	13	10	235	35	8	9	3	27
1943-44	..	100	44	46	6	8	9	196	40	3	26	4	34
1944-45	..	87	33	31	8	9	7	182	38	5	29	2	58
1945-46	..	422	35	51	8	16	9	213	52	6	33	2	23
1946-47	..	108	33	51	5	265	5	220	54	7	24	2	28
1947-48	..	142	28	44	9	7	4	216	40	17	11	4	39
1948-49	..	143	28	36	414	7	6	195	42	6	8	6	66

Year.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921-22	11	35	324	600	54	21	123	101	219	84	19	6
1922-23	6	27	332	525	46	21	103	75	257	75	30	8
1223-24	6	14	265	473	49	14	115	66	262	75	18	1
1924-25	6	24	187	463	48	23	91	60	217	96	18	1
1925-26	12	18	269	417	47	21	76	27	153	89	21	1
1926-27	7	20	256	498	28	18	85	32	163	60	18	1
1927-28	2	20	269	425	41	22	106	47	132	74	20	2
1928-29	4	43	333	382	63	27	91	39	146	67	19	3
1929-30	4	24	357	531	100	23	108	42	264	76	22	4
1930-31	5	23	353	619	98	25	113	61	189	114	20	5
1931-32	7	32	409	681	91	24	126	55	183	115	21	5
1932-33	10	32	423	908	186	21	178	71	245	113	27	..
1933-34	8	28	317	964	125	16	156	52	262	123	22	6
1934-35	44	27	273	800	96	16	181	35	218	107	20	6
1935-36	35	33	303	789	99	21	144	40	204	119	24	..
1936-37	29	32	314	790	108	19	153	58	230	93	25	1
1937-38	22	34	297	843	122	19	157	58	185	136	24	7
1938-39	20	40	333	764	177	25	130	48	165	107	24	7
1939-40	20	38	348	799	127	18	120	44	160	118	25	7
1940-41	20	53	323	806	119	45	181	56	177	92	28	10
1941-42	18	39	330	876	121	32	161	45	167	111	20	7
1942-43	17	76	359	1,066	134	21	174	38	191	90	46	8
1943-44	16	44	339	885	135	29	142	39	188	88	41	9
1944-45	20	46	327	912	134	38	133	19	206	76	27	9
1945-46	35	56	282	971	123	40	135	20	157	75	32	6
1946-47	32	61	312	834	114	16	121	23	168	67	36	2
1947-48	28	49	297	888	103	27	138	18	79	113	31	6
1948-49	25	54	291	917	125	38	133	15	144	99	35	2

APPENDIX XXVI.

Area sown with crops.

Chillies in 00 acres.

Year.	Visakhapatnam.	East Godavari.	West Godavari.	Kistna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921-22 ..	128	175		161	1,194	175	69	67	46	80	32	25	53	31	91	155	106	62	92	109	173	36	55	..
1922-23 ..	150	253		234	1,215	218	83	76	46	100	28	16	57	29	99	165	90	50	85	108	215	30	58	1
1923-24 ..	168	279		277	881	167	72	56	37	99	29	16	58	36	89	137	84	52	76	99	231	34	57	1
1924-25 ..	173	181	55	134	1,095	190	83	69	44	104	26	18	48	35	85	115	69	56	50	90	213	34	56	1
1925-26 ..	179	225	46	124	886	198	88	77	52	85	27	15	58	37	78	113	71	54	73	86	212	35	67	..
1926-27 ..	186	245	72	200	1,308	202	91	77	43	86	26	20	55	34	70	124	75	58	85	93	204	36	56	..
1927-28 ..	187	245	72	179	985	251	123	95	47	67	30	20	56	39	76	135	87	55	107	105	259	37	58	1
1928-29 ..	184	219	65	154	659	167	80	80	31	79	25	18	57	31	77	99	78	50	93	82	225	37	59	1
1929-30 ..	180	243	75	132	485	160	62	59	42	92	23	19	53	40	61	102	73	49	78	90	192	37	57	..
1930-31 ..	189	247	94	155	709	246	86	97	63	94	25	24	54	49	89	119	89	57	100	104	266	38	56	..
1931-32 ..	340	197	104	154	717	250	108	107	62	112	27	22	64	44	117	166	106	44	108	99	239	33	58	..
1932-33 ..	346	186	82	107	498	156	101	82	41	112	33	16	61	39	89	122	90	44	85	82	221	41	58	..
1933-34 ..	328	242	904	113	460	228	111	90	56	102	32	24	68	46	98	126	116	64	89	113	218	43	60	..
1934-35 ..	345	359	149	246	1,038	442	191	117	88	161	47	36	82	60	140	142	155	66	118	154	259	44	59	1
1935-36 ..	334	268	106	171	675	257	153	98	55	147	47	28	59	50	110	107	107	44	95	144	207	47	60	..
1936-37 ..	183	188	72	90	346	172	93	107	60	123	46	23	61	55	96	84	98	47	86	147	207	49	63	1
1937-38 ..	204	287	115	113	448	150	86	95	49	121	46	24	65	52	94	91	108	55	84	151	248	53	63	1
1938-39 ..	208	258	86	106	573	257	129	117	80	127	54	31	74	69	116	127	138	61	112	198	309	49	66	1
1939-40 ..	205	226	99	117	557	299	146	114	88	132	51	30	61	58	119	115	122	61	101	190	259	53	67	1
1940-41 ..	202	164	61	103	559	235	122	119	72	118	45	28	60	66	119	141	123	52	113	186	226	61	65	1
1941-42 ..	210	212	62	110	525	196	107	95	53	118	36	22	62	67	107	117	101	51	97	178	263	59	51	1
1942-43 ..	206	210	88	140	710	230	99	106	64	115	41	23	61	80	121	127	113	50	86	177	221	57	62	1
1943-44 ..	157	233	97	152	829	257	106	113	60	129	39	28	54	78	110	112	115	53	93	172	281	60	68	1
1944-45 ..	130	196	99	131	674	213	98	103	55	118	33	31	55	85	100	72	89	42	68	138	186	66	69	1
1945-46 ..	180	202	103	124	579	247	112	109	67	117	45	32	61	82	119	105	106	59	71	128	184	56	66	1
1946-47 ..	125	270	144	174	869	462	173	120	83	117	27	16	55	64	124	110	113	46	78	113	215	72	70	..
1947-48 ..	122	216	127	148	999	302	168	124	54	92	49	27	67	86	151	117	149	56	105	96	245	65	86	..
1948-49 ..	121	214	117	135	769	357	140	128	54	134	50	34	62	61	120	109	143	55	78	154	178	64	82	..

APPENDIX XXVII.

Area sown with crops.

Including Pepper, Ginger, Coriander, Turmeric, Garlic, and Tamarind.

Year.	Vizakhapatnam.	East Godavari.	West Godavari.	Kistna.	Guntur.	Kurnool.	Bellary.	Anantapur.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1921–22 ..	8	94		145	816	33	40	96
1922–23 ..	13	73		129	888	47	79	154
1923–24 ..	269	105		120	892	41	47	74
1924–25 ..	329	116	59	82	440	56	41	81
1925–26 ..	336	126	41	83	508	39	72	121
1926–27 ..	359	60	22	37	327	25	55	137
1927–28 ..	279	70	17	55	385	27	69	124
1928–29 ..	298	125	37	50	532	38	161	194
1929–30 ..	298	77	43	47	324	33	84	133
1930–31 ..	299	54	23	57	288	32	48	103
1931–32 ..	295	83	50	116	536	36	93	199
1932–33 ..	300	80	52	91	427	46	70	125
1933–34 ..	300	85	61	101	453	37	43	93
1934–35 ..	296	86	53	120	579	46	55	117
1935–36 ..	36	95	66	91	513	29	52	90
1936–37	33	65	50	90	360	36	73	104
1937–38	40	40	33	59	295	40	96	142
1938–39 ..	36	69	50	44	244	40	73	118
1939–40 ..	34	69	55	57	436	41	181	186
1940–41 ..	41	77	73	67	467	49	143	168
1941–42 ..	48	60	43	60	362	47	91	137
1942–43 ..	41	50	39	45	391	34	33	78
1943–44 ..	50	42	34	51	389	34	56	90
1944–45 ..	50	36	46	59	395	46	115	135
1945–46 ..	51	45	71	61	492	69	80	136
1946–47 ..	48	122	70	85	470	127	155	180
1947–48 ..	47	75	55	50	312	53	204	165
1948–49 ..	66	67	56	46	323	39	61	118

Year.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.
(1)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
1921–22	86	38	13	52	69	62	100	103	201
1922–23	92	22	19	30	84	67	118	99	196
1923–24	93	23	12	54	84	80	80	106	202
1924–25	116	31	11	52	82	64	76	124	181
1925–26	132	32	9	56	89	67	101	89	174
1926–27	87	40	8	35	89	62	74	79	153
1927–28	84	32	6	48	74	65	64	100	147
1928–29	120	39	7	63	84	52	74	129	224
1929–30	126	26	6	50	73	62	66	122	201
1930–31	87	24	8	50	63	51	57	100	184
1931–32	134	27	10	75	75	82	83	99	206
1932–33	120	27	9	92	68	64	82	135	248
1933–34	94	39	7	69	66	63	84	98	242
1934–35	141	23	8	78	84	62	102	78	302
1935–36	83	23	8	82	70	57	79	63	242
1936–37	72	19	9	61	68	54	86	92	236
1937–38	87	20	7	52	75	52	81	100	188
1938–39	86	20	27	35	71	53	62	74	192
1939–40	157	18	10	44	69	50	83	71	235
1940–41	170	21	9	54	69	54	103	154	236
1941–42	122	19	9	46	84	56	115	152	208
1942–43	81	16	9	52	95	48	93	120	211
1943–44	91	17	9	61	71	44	87	116	202
1944–45	93	20	8	60	63	41	87	53	196
1945–46	149	42	7	46	77	47	109	118	411
1946–47	205	45	8	88	69	36	93	145	268
1947–48	89	8	6	26	74	37	88	122	160
1948–49	88	19	7	35	68	39	90	77	155

Year.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22	30	90	75	112	1,001	90	4
1922–23	31	92	70	107	998	94	5
1923–24	62	102	79	113	1,058	94	5
1924–25	34	98	57	103	1,059	92	5
1925–26	38	90	52	149	1,072	94	4
1926–27	33	88	40	89	1,064	95	5
1927–28	34	128	51	96	1,073	95	6
1928–29	36	87	71	103	1,068	97	5
1929–30	33	98	77	32	1,096	110	5
1930–31	34	91	60	56	1,107	109	6
1931–32	31	93	70	131	1,173	109	6
1932–33	32	97	94	154	1,228	110	6
1933–34	48	104	95	87	1,213	113	7
1934–35	34	97	101	164	1,211	108	6
1935–36	29	107	119	188	1,196	113	9
1936–37	30	100	96	171	1,250	113	6
1937–38	30	104	88	204	1,260	114	7
1938–39	31	112	90	228	1,240	116	10
1939–40	34	144	79	238	1,262	115	15
1940–41	37	67	75	188	1,266	618	11
1941–42	33	79	69	210	1,294	107	20
1942–43	31	71	67	206	1,271	110	21
1943–44	33	80	58	198	1,307	112	25
1944–45	36	113	54	167	1,275	116	24
1945–46	29	115	42	303	1,229	115	23
1946–47	28	118	30	292	1,215	123	21
1947–48	29	113	27	206	1,177	122	19
1948–49	30	106	25	177	1,185	123	20

APPENDIX XXVIII.

Area sown with crops.

Sugarcane (in 00 acres).

Year.		Visakhapatnam.	East Godavari.	West Godavari	Krishna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1921–22	..	244	128	..	15	..	2	91	35	3	..	1	77
1922–23	..	274	122	..	19	1	3	100	32	4	..	1	95
1923–24	..	364	112	..	20	1	3	94	26	5	..	1	69
1924–25	..	332	89	13	1	..	2	82	13	3	..	1	89
1925–26	..	354	92	14	1	..	5	87	19	4	..	1	75
1926–27	..	359	98	12	1	1	5	78	25	5	..	1	74
1927–28	..	367	71	10	..	2	2	87	22	3	..	2	66
1928–29	..	361	60	7	..	2	1	68	19	2	..	1	54
1929–30	..	351	77	8	..	3	1	79	18	2	..	2	59
1930–31	..	343	87	11	1	4	3	94	25	4	1	3	101
1931–32	..	329	73	11	..	5	3	93	33	5	..	3	105
1932–33	..	336	75	12	..	7	2	78	31	4	..	3	102
1933–34	..	345	92	16	6	11	2	85	26	3	..	3	98
1934–35	..	339	90	19	26	16	4	77	27	3	..	3	116
1935–36	..	293	99	21	40	14	7	92	18	4	1	5	128
1936–37	..	323	103	24	23	13	8	5	28	5	1	4	102
1937–38	..	308	82	20	24	6	5	77	25	3	..	2	76
1938–39	..	288	67	18	26	3	48	70	16	2	..	2	97
1939–40	..	331	88	21	44	4	5	123	26	5	..	3	153
1940–41	..	348	112	28	46	3	6	133	35	7	..	5	225
1941–42	..	279	86	21	17	2	5	95	26	3	..	3	118
1942–43	..	328	77	20	13	4	3	82	25	4	..	2	126
1943–44	..	323	94	22	20	2	4	101	32	6	..	5	191
1944–45	..	280	97	27	35	2	5	96	39	6	..	4	188
1945–46	..	265	99	32	39	2	6	102	55	6	..	4	185
1946–47	..	315	140	69	36	28	8	106	71	11	..	5	241
1947–48	..	302	172	92	46	4	6	153	102	25	1	9	366
1948–49	..	376	156	49	77	2	8	82	57	5	1	2	187

Year.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22	115	28	66	97	84	8	29	5	2	1	32	..
1922–23	132	42	63	118	92	10	31	5	2	1	3	..
1923–24	120	40	54	111	62	7	25	5	2	1	36	..
1924–25	111	36	52	90	67	8	19	5	2	1	25	..
1925–26	105	45	43	96	64	10	17	5	2	1	37	..
1926–27	109	47	47	103	57	8	21	3	2	1	36	..
1927–28	81	39	41	90	59	6	21	3	3	1	35	..
1928–29	61	23	28	66	35	5	18	3	2	..	36	..
1929–30	75	30	27	68	53	6	21	3	2	..	36	..
1930–31	80	51	45	84	78	8	28	5	3	..	36	..
1931–32	102	78	64	86	48	6	23	6	3	36	..	..
1932–33	110	90	69	88	70	7	23	3	36	..	..	..
1933–34	100	79	67	87	53	9	21	3	3	..	37	..
1934–35	94	74	73	84	58	6	26	4	3	..	37	..
1935–36	105	98	61	85	68	7	20	3	2	..	39	..
1936–37	115	117	49	63	55	7	13	2	2	..	40	..
1937–38	79	63	41	58	42	6	14	2	2	..	42	..
1938–39	68	58	49	75	68	8	17	3	2	..	42	..
1939–40	95	94	72	115	111	12	23	4	2	..	45	..
1940–41	107	136	99	111	117	15	31	6	2	1	43	..
1941–42	84	83	71	76	51	6	20	5	2	1	48	..
1942–43	91	92	75	100	86	8	27	5	2	2	47	..
1943–44	122	184	105	128	126	13	47	9	1	1	59	..
1944–45	60	179	98	96	119	13	46	4	2	2	55	..
1945–46	166	183	91	104	133	12	48	7	2	1	64	..
1946–47	189	190	100	148	171	20	94	16	4	2	65	..
1947–48	249	333	168	204	230	38	160	20	7	2	69	..
1948–49	116	140	105	149	129	12	51	7	2	2	[illegible]	..

APPENDIX XXIX.

Area sown with crops.

Sugar (Others) (in 00 acres).

Year.	Visakhapatnam.	East Godavari.	West Godavari.	Krishna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22 ..	1	1	..	9	42	10	2	37	9	16	17	9	15	23	8	4	4	26	10	11	379	116	4	..
1922–23 ..	1	1	..	36	40	9	1	52	11	19	19	12	18	18	5	5	4	23	9	17	374	112	4	..
1923–24 ..	13	3	..	33	43	13	1	64	11	6	22	8	19	20	6	4	3	22	10	16	371	115	4	..
1924–25 ..	13	7	8	36	45	5	3	46	9	20	20	12	19	17	6	5	3	23	13	75	341	144	4	..
1925–26 ..	12	1	1	7	42	4	3	95	7	13	14	13	17	23	6	4	3	21	10	15	357	138	4	..
1926–27 ..	11	5	11	32	48	2	1	102	6	21	14	13	21	20	6	4	3	24	11	13	344	125	4	..
1927–28 ..	12	3	13	30	43	19	..	66	2	31	13	12	22	21	7	3	3	27	11	21	338	129	3	..
1928–29 ..	12	2	7	30	43	11	2	93	3	27	13	13	21	23	7	6	4	31	10	22	333	130	3	..
1929–30 ..	12	3	8	25	39	9	44	102	7	12	11	9	12	15	6	3	5	31	11	25	323	129	4	..
1930–31 ..	11	3	7	40	36	9	1	141	8	23	15	9	12	19	6	6	4	26	12	21	320	174	4	..
1931–32 ..	28	8	7	17	34	11	4	134	9	15	15	13	17	22	6	6	5	38	11	21	320	161	4	..
1932–33 ..	29	7	9	23	29	11	7	117	11	16	19	13	19	21	8	6	4	25	13	23	318	150	4	..
1933–34 ..	28	4	9	22	34	8	5	127	13	16	20	13	18	19	9	7	4	29	12	55	321	117	4	..
1934–35 ..	28	6	10	21	35	13	6	126	10	20	22	12	21	19	11	9	4	27	14	17	319	156	4	..
1935–36 ..	14	10	11	24	41	12	8	95	12	14	19	13	20	22	7	12	4	25	14	18	323	144	4	..
1936–37 ..	20	8	12	12	40	10	37	88	11	14	18	12	19	23	9	12	4	25	15	19	381	118	4	..
1937–38 ..	26	11	9	13	44	10	35	76	14	16	18	13	21	22	7	13	4	29	16	20	388	118	4	..
1938–39 ..	22	8	8	13	41	3	36	108	10	16	16	14	21	28	8	14	4	29	15	31	389	120	4	..
1939–40 ..	19	7	8	12	37	..	36	99	10	15	16	12	22	23	8	15	4	23	14	32	379	108	4	..
1940–41 ..	22	7	8	11	37	..	11	125	11	15	17	14	20	22	9	16	4	23	14	37	385	98	4	..
1941–42 ..	23	5	8	11	35	8	5	104	11	18	16	13	18	22	7	16	4	23	13	42	381	101	4	..
1942–43 ..	24	3	9	12	37	..	26	71	9	18	16	15	19	22	8	17	4	23	13	42	385	102	4	..
1943–44 ..	26	2	11	10	37	3	16	66	10	14	15	12	19	20	8	17	4	23	14	43	388	105	4	..
1944–45 ..	26	2	10	10	38	4	21	87	10	14	16	13	15	18	11	15	4	24	14	64	336	94	4	..
1945–46 ..	48	2	9	10	38	3	21	55	10	15	16	13	21	19	8	15	4	24	12	24	327	101	4	..
1946–47 ..	20	50	11	10	35	4	22	72	11	14	15	13	16	20	7	14	3	25	15	23	372	107	4	..
1947–48 ..	30	1	11	9	32	1	22	47	8	11	17	12	13	19	9	14	4	27	14	17	357	121	4	..
1948–49 ..	30	1	9	9	35	..	19	19	9	13	16	12	13	30	8	14	6	22	14	21	354	102	4	..

APPENDIX XXX.

Area sown with crops.

Mango in 00 acres.

Year.	Visakhapatnam.	East Godavari.	West Godavari.	Krishna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22	183	..	181	153	25	31	26	30	87	57	41	15	187	133	59	3	24	63	28	6	7	474	19	..
1922–23	183	..	205	152	25	31	25	29	83	75	47	12	192	136	54	4	25	66	27	6	7	471	26	..
1923–24	429	..	190	152	25	31	23	29	84	57	54	15	195	145	36	4	25	63	27	6	7	479	24	..
1924–25	428	206	76	82	24	35	25	33	80	69	53	22	188	140	37	4	27	64	24	7	8	484	24	..
1925–26	444	238	71	84	24	31	20	32	99	53	37	22	211	152	40	4	24	62	23	9	7	474	24	..
1926–27	466	241	78	86	25	32	19	39	90	52	33	17	226	161	40	4	24	58	25	8	9	477	25	..
1927–28	417	253	82	91	24	31	24	35	62	54	31	17	234	156	40	4	23	65	29	7	9	477	24	..
1928–29	388	262	86	95	22	31	25	38	110	40	31	18	243	148	43	4	25	63	32	8	10	484	27	..
1929–30	405	289	90	90	21	32	22	30	136	54	20	17	234	144	42	4	26	64	45	8	12	481	25	..
1930–31	403	290	86	70	25	40	23	40	113	46	27	24	231	149	41	4	25	67	38	7	10	505	26	..
1931–32	387	301	92	95	23	34	24	44	116	65	44	23	253	142	43	4	25	67	37	6	10	501	25	..
1932–33	391	317	96	92	22	36	24	46	131	60	49	19	271	145	45	5	25	65	32	8	11	513	25	..
1933–34	390	316	100	90	26	35	22	45	132	61	66	21	290	137	49	5	25	71	35	7	12	495	26	..
1934–35	402	332	104	96	26	37	23	44	147	61	68	23	300	139	56	6	25	59	41	7	11	493	25	..
1935–36	324	332	100	112	24	39	23	47	150	62	54	26	292	161	59	7	25	51	38	8	11	491	23	..
1936–37	291	340	103	117	25	38	24	46	153	66	54	25	295	155	61	6	25	59	41	8	12	477	28	..
1937–38	269	323	105	99	25	37	24	45	149	66	49	26	298	159	65	6	26	50	39	8	11	503	25	..
1938–39	258	324	109	118	25	39	24	48	161	65	75	26	326	161	68	6	25	50	40	9	11	498	27	..
1939–40	268	343	110	122	22	40	24	46	162	66	78	26	301	152	55	6	26	51	42	9	12	520	28	..
1940–41	271	344	106	149	22	40	24	52	160	64	79	25	301	160	73	6	25	47	43	9	12	505	27	..
1941–42	340	339	121	145	24	39	23	52	164	64	79	28	306	154	76	6	26	45	44	9	13	502	28	..
1942–43	325	334	121	197	22	39	23	47	162	65	74	28	304	151	77	5	26	96	41	9	14	449	27	..
1943–44	291	320	113	157	21	36	21	43	161	58	75	28	306	146	76	5	27	47	49	10	14	456	29	..
1944–45	287	313	120	148	21	38	22	54	159	57	78	27	299	133	83	6	27	48	52	9	14	420	31	..
1945–46	302	313	123	160	20	33	22	54	137	55	74	25	203	140	80	6	27	45	52	9	15	457	31	..
1946–47	304	299	97	140	21	38	22	56	159	61	46	28	285	136	84	6	27	46	49	9	15	476	33	..
1947–48	273	218	122	148	24	36	21	42	164	61	62	28	241	129	86	7	26	42	56	9	16	418	34	..
1948–49	361	256	128	167	21	45	22	56	163	61	69	27	261	132	92	24	36	44	69	10	16	457	32	..

APPENDIX XXXI.

Area sown with crops.

Bananas (in 00 acres).

Year.	Visakhapatnam.	East Godavari.	West Godavari.	Krishna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22 ..	7	..	77	32	5	2	5	..	1	3	13	10	16	6	49	40	99	111	126	43	63	481	26	4
1922–23 ..	17	..	35	41	4	2	4	..	1	3	13	11	16	6	46	38	94	109	130	38	64	475	27	6
1923–24 ..	79	..	36	41	4	1	4	..	1	3	12	10	16	5	41	29	83	107	127	38	59	461	24	6
1924–25 ..	38	31	38	2	4	2	3	..	1	2	13	11	15	3	33	23	76	106	125	35	67	473	25	5
1925–26 ..	37	54	41	2	6	1	3	..	1	3	15	11	8	3	29	23	81	112	134	50	70	473	25	6
1926–27 ..	36	48	43	2	6	2	4	..	2	2	15	13	8	5	37	29	91	111	139	48	58	485	25	6
1927–28 ..	37	48	40	2	6	3	5	..	..	3	14	12	7	3	39	29	87	110	140	48	68	500	26	6
1928–29 ..	39	46	39	7	8	4	5	2	4	3	15	11	7	3	34	31	86	111	140	43	62	507	29	5
1929–30 ..	37	54	46	4	8	3	6	..	1	4	15	11	7	4	33	34	87	118	142	49	66	501	30	5
1930–31 ..	37	61	49	5	10	4	6	..	2	3	25	13	6	6	41	48	101	123	151	39	74	514	23	5
1931–32 ..	35	50	45	5	10	4	6	..	3	6	28	17	7	11	47	52	100	123	162	38	69	559	33	6
1932–33 ..	38	56	52	5	9	5	6	..	4	14	25	17	8	16	53	52	86	120	160	34	75	545	35	7
1933–34 ..	37	69	59	6	13	5	9	..	4	6	24	21	9	21	59	62	93	124	167	37	89	546	35	7
1934–35 ..	39	68	57	6	18	4	13	..	4	7	25	20	11	19	65	64	100	116	180	44	84	526	36	7
1935–36 ..	44	52	45	6	9	3	10	1	2	5	24	14	10	12	48	51	88	104	171	29	65	529	33	7
1936–37 ..	33	57	50	6	8	3	8	1	2	5	22	12	4	8	42	40	75	104	173	32	72	529	34	7
1937–38 ..	34	66	48	18	7	3	8	1	2	5	19	12	3	9	36	42	85	108	177	29	79	550	38	7
1938–39 ..	34	63	47	4	6	3	10	2	2	7	20	16	4	9	39	48	95	118	180	32	72	528	37	7
1939–40 ..	34	57	41	4	5	3	10	2	1	5	22	17	5	9	37	48	88	119	168	28	63	560	37	8
1940–41 ..	37	47	41	3	6	3	9	1	1	3	22	17	5	11	40	45	79	118	164	47	62	557	38	7
1941–42 ..	43	44	41	4	17	4	9	1	2	5	20	15	3	12	41	52	77	118	165	46	64	557	35	7
1942–43 ..	34	44	38	4	8	3	10	1	3	6	17	15	4	13	42	54	80	117	166	40	60	520	38	8
1943–44 ..	40	40	44	6	8	3	9	1	5	7	17	13	4	12	41	48	87	124	165	47	57	482	39	8
1944–45 ..	38	49	49	4	11	2	8	..	8	10	18	13	3	16	44	40	107	132	178	53	78	505	39	9
1945–46 ..	49	55	50	5	15	3	8	1	10	10	20	15	4	22	48	49	129	130	186	58	90	563	44	9
1946–47 ..	45	62	68	5	16	3	8	..	6	10	25	17	6	17	44	57	143	126	198	50	92	573	46	8
1947–48 ..	40	79	75	5	9	3	9	..	7	11	21	21	24	18	54	79	170	129	190	30	108	548	48	8
1948–49 ..	48	71	69	7	10	3	10	2	5	11	20	20	4	17	50	69	151	125	184	26	88	561	48	7

APPENDIX XXX II.

Other fruits and vegetables including root crops.

Includes Onions, Potatoes, Sweet potatoes, Tapioca, Citrus variety, etc.

Year. (1)	Visakhapatnam. (2)	East Godavari. (3)	West Godavari. (4)	Krishna. (5)	Guntur. (6)	Kurnool. (7)	Bellary. (8)	Anantapur. (9)	Cuddapah. (10)	Nellore. (11)	Chingleput. (12)	South Arcot. (13)
1921–22 ..	215	..	108	78	67	45	63	53	71	22	69	218
1922–23 ..	254	..	105	102	52	27	38	53	96	20	60	271
1923–24 ..	404	..	158	115	45	26	37	30	62	16	58	245
1924–25 ..	352	280	71	33	56	38	34	69	54	25	50	214
1925–26 ..	355	97	120	42	58	36	41	65	58	37	53	174
1926–27 ..	362	113	91	50	63	39	39	60	72	38	43	170
1927–28 ..	283	113	96	62	66	42	30	80	92	21	40	173
1928–29 ..	294	97	115	45	72	24	38	45	59	25	47	180
1929–30 ..	297	108	102	48	69	27	32	46	74	28	53	175
1930–31 ..	294	112	88	78	86	42	39	47	75	21	33	164
1931–32 ..	253	115	102	38	140	44	41	75	89	23	34	186
1932–33 ..	252	106	102	55	84	32	37	66	87	26	82	180
1933–34 ..	254	120	116	60	83	40	33	44	94	27	94	182
1934–35 ..	254	141	122	70	104	41	54	58	102	31	61	189
1935–36 ..	131	152	115	55	87	32	42	51	94	28	81	199
1936–37 ..	522	117	103	53	88	38	35	57	114	23	71	196
1937–38 ..	157	145	107	49	95	32	36	65	117	23	49	192
1938–39 ..	177	153	129	54	93	41	44	52	130	26	71	101
1939–40 ..	174	156	126	50	100	38	41	50	131	29	65	82
1940–41 ..	221	165	109	54	99	34	31	42	109	30	71	74
1941–42 ..	209	175	97	47	84	45	38	53	129	31	63	213
1942–43 ..	213	176	106	50	105	65	59	61	152	32	68	121
1943–44 ..	186	178	100	49	89	42	38	41	119	26	60	173
1944–45 ..	142	181	100	50	115	41	40	55	112	26	52	135
1945–46 ..	178	180	141	62	139	61	47	76	196	28	59	196
1946–47 ..	171	222	125	58	140	338	55	53	138	47	44	192
1947–48 ..	185	145	108	55	115	45	43	71	151	40	73	142
1948–49 ..	226	199	111	64	115	50	26	54	175	43	59	115

Year. (1)	Chittoor. (14)	North Arcot. (15)	Salem. (16)	Coimbatore. (17)	Tiruchirappalli. (18)	Tanjore. (19)	Madurai. (20)	Ramanathapuram. (21)	Tirunelveli. (22)	Malabar. (23)	South Kanara. (24)	The Nilgiris. (25)
1921–22 ..	35	77	91	65	94	138	102	30	91	593	142	101
1922–23 ..	36	72	99	82	112	153	108	29	104	726	150	95
1923–24 ..	52	74	48	76	104	142	85	35	85	689	138	97
1924–25 ..	40	82	33	75	121	133	97	48	93	717	145	98
1925–26 ..	49	51	36	77	113	145	101	120	97	761	162	96
1926–27 ..	45	57	29	106	119	116	120	116	81	805	162	94
1927–28 ..	39	52	44	104	134	123	101	94	103	802	168	92
1928–29 ..	26	80	49	79	110	120	113	102	99	838	186	95
1929–30 ..	27	57	47	96	108	135	117	119	90	851	168	108
1930–31 ..	21	60	51	92	101	110	113	56	91	848	162	126
1931–32 ..	33	63	74	116	119	113	139	68	110	942	184	118
1932–33 ..	32	72	59	97	111	102	108	54	101	989	165	119
1933–34 ..	32	69	58	98	130	84	126	55	115	911	175	128
1934–35 ..	38	86	61	94	148	107	128	58	115	816	168	144
1935–36 ..	27	75	54	80	143	87	127	69	108	851	183	146
1936–37 ..	27	92	59	104	159	97	146	64	127	941	233	146
1937–38 ..	26	76	49	76	151	90	106	71	109	930	212	161
1938–39 ..	36	86	67	89	179	68	146	89	116	931	226	161
1939–40 ..	30	88	70	83	208	74	130	56	111	883	205	151
1940–41 ..	29	86	58	107	209	98	123	74	117	962	187	175
1941–42 ..	33	86	71	120	230	86	157	81	112	1,041	178	174
1942–43 ..	44	99	62	88	239	86	113	66	94	1,077	185	177
1943–44 ..	29	69	62	82	250	96	144	69	107	1,058	252	243
1944–45 ..	28	72	102	69	249	88	123	62	97	1,155	271	234
1945–46 ..	37	98	119	113	277	90	184	97	117	1,188	268	220
1946–47 ..	35	68	72	81	254	104	131	81	109	1,142	283	206
1947–48 ..	33	84	133	118	272	71	162	58	105	1,285	317	172
1948–49 ..	33	85	134	90	294	111	152	55	104	1,350	201	183

APPENDIX XXXIII.

Miscellaneous Food Crops (in 00 acres).

Year.	Visakhapatnam.	East Godavari.	West Godavari.	Kistna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22	..	1	..	13	1	4	2	..	..	5	7	14	25	8	29	4	4	15	7	5	13	227	..	1
1922–23	10	..	..	10	6	1	2	3	..	..	9	13	21	7	11	1	3	36	10	14	3	179	..	1
1923–24	122	21	..	8	14	3	..	33	..	128	22	11	18	8	20	1	5	14	4	17	3	172	..	1
1924–25	119	11	..	10	5	1	..	25	..	229	29	10	16	13	97	2	4	18	13	6	9	158	1	..
1925–26	115	2	12	8	2	..	..	15	..	5	26	5	16	7	64	1	1	13	13	56	8	179	..	1
1926–27	112	..	10	9	4	..	1	9	..	1	40	21	15	9	63	2	1	..	..	12	8	136	..	1
1927–28	92	2	8	6	9	..	..	5	..	..	32	7	16	7	63	2	9	..	4	61	4	156	..	..
1928–29	102	7	..	6	3	..	..	11	..	2	30	8	22	7	65	..	..	..	3	4	7	137	..	..
1929–30	102	9	8	7	17	4	..	18	5	9	29	14	9	5	12	3	..	9	7	7	18	78	..	1
1930–31	103	4	6	11	3	..	..	4	8	6	28	28	16	5	21	2	8	38	..	18	16	234	..	..
1931–32	188	23	3	10	9	1	6	11	4	16	25	99	1	3	9	2	1	31	1	19	13	162	..	..
1932–33	167	4	1	8	9	7	2	4	5	40	39	86	1	3	5	..	4	60	24	17	16	194	..	1
1933–34	156	10	3	6	32	1	..	2	17	31	7	33	1	4	8	..	6	26	21	25	86	168	..	1
1934–35	155	10	3	8	11	3	..	3	19	10	22	20	..	3	6	..	..	23	9	13	32	230	..	1
1935–36	37	8	2	3	8	3	1	1	20	5	14	13	1	2	3	..	..	36	3	25	13	128	..	1
1936–37	30	16	3	4	9	3	..	21	14	2	20	12	1	2	4	..	..	29	2	16	14	95	..	1
1937–38	29	14	2	9	8	10	11	3	7	12	20	12	8	1	31	..	2	32	5	14	10	156	..	1
1938–39	30	11	2	4	5	4	..	2	30	4	11	16	3	3	1	..	..	51	15	20	16	261	..	1
1939–40	27	50	9	9	2	2	..	3	38	3	6	19	4	1	5	..	..	50	7	17	16	240	..	1
1940–41	10	10	1	2	3	6	..	6	8	3	16	12	6	1	6	..	..	28	3	11	11	147	..	1
1941–42	20	11	2	43	3	8	..	4	4	6	13	9	7	2	2	..	..	36	4	16	9	130	..	1
1942–43	26	44	3	9	5	7	..	15	5	30	3	20	5	1	6	..	..	35	5	18	7	134	..	1
1943–44	22	21	20	5	8	3	2	3	3	16	6	1	4	1	4	..	..	33	8	86	6	213	..	1
1944–45	25	36	12	6	2	6	3	7	3	3	20	10	5	4	14	..	..	37	3	107	7	259	1	1
1945–46	23	18	7	5	5	6	11	24	3	8	18	22	6	5	7	10	..	40	19	57	12	296	1	..
1946–47	20	26	..	5	8	3	5	5	9	2	8	19	..	1	8	2	..	33	20	57	4	107	1	..
1947–48	10	40	8	9	8	7	..	..	6	2	5	3	3	3	7	2	..	38	2	2	11	158	1	..
1948–49	32	12	13	3	9	13	18	26	6	4	12	7	6	..	30	1	29	36	17	1	7	243	1	..

APPENDIX XXXIV.

Groundnuts (in 00 acres).

Year.	Visakhapatnam.	East Godavari.	West Godavari.	Krishna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22	432	..	..	21	89	800	190	1,089	1,301	12	250	3,867	334	2,088	661	786	904	820	453	254	22	7	..	..
1922–23	501	..	..	32	128	1,370	376	1,291	1,949	10	254	3,846	434	2,327	866	1,085	1,032	887	627	246	23	6	..	..
1923–24	599	..	..	53	132	2,000	641	1,590	1,704	13	301	3,729	498	2,133	994	1,026	890	832	481	241	23	6	..	..
1924–25	695	2	42	72	361	2,299	615	1,054	1,375	56	341	4,220	568	2,560	826	1,084	924	835	492	281	26	5	..	..
1925–26	895	4	79	81	612	3,502	1,072	1,725	2,236	93	521	4,660	883	3,638	1,304	1,387	1,147	951	530	268	39	10	..	..
1926–27	914	3	52	85	777	3,578	1,806	2,559	2,514	62	503	3,968	1,089	3,638	938	1,257	941	902	498	299	35	14	..	..
1927–28	885	4	49	151	1,378	4,237	2,791	3,495	2,703	62	562	4,533	1,381	4,610	1,431	1,432	1,153	917	706	390	44	18	..	..
1928–29	963	5	43	266	2,219	4,790	3,156	4,254	2,721	107	586	4,830	1,369	4,608	1,560	1,720	1,110	906	769	336	46	23	..	..
1929–30	112	3	27	310	2,390	3,285	2,823	2,111	1,636	133	622	4,557	1,202	4,431	1,739	1,749	1,189	918	910	379	45	26	..	..
1930–31	1,336	5	39	524	3,048	4,423	3,321	3,496	2,357	138	509	4,587	844	3,720	1,520	1,847	1,060	867	1,018	465	57	29	..	..
1931–32	1,310	3	29	438	2,053	3,963	2,374	2,477	1,834	79	277	3,377	654	2,470	824	1,267	826	656	555	372	53	21	..	..
1932–33	1,179	1	38	708	3,183	6,146	3,403	3,435	2,648	123	388	3,352	1,066	3,051	1,283	1,666	856	671	928	491	72	10	..	..
1933–34	1,264	2	65	1,093	3,529	4,801	4,166	4,465	2,295	166	390	3,820	1,138	2,950	1,515	2,000	960	651	1,293	589	129	15	..	..
1934–35	1,263	3	51	921	1,849	2,794	1,585	2,541	1,263	66	336	2,898	776	2,187	729	1,343	847	491	610	332	103	11	..	..
1935–36	1,703	3	108	1,025	2,084	3,166	1,098	1,803	1,194	112	414	3,749	965	2,760	979	1,251	1,448	551	644	348	86	9	..	..
1936–37	1,836	11	215	1,602	3,058	4,682	2,290	3,156	2,029	181	658	4,298	1,415	3,486	1,378	1,420	1,169	628	877	409	107	34	..	..
1937–38	2,051	42	520	2,082	4,176	5,919	3,767	4,464	2,873	256	809	4,713	2,019	3,499	1,928	2,006	1,336	689	1,611	646	221	47	..	..
1938–39	2,205	41	320	1,626	3,132	4,109	2,479	3,181	1,849	325	711	4,257	1,747	4,023	1,611	1,894	1,334	632	1,403	596	192	49	..	..
1939–40	2,594	81	219	1,603	3,088	4,052	3,385	3,218	1,608	287	666	4,001	1,425	3,556	1,395	1,604	1,253	551	1,005	434	149	51	..	..
1940–41	2,425	35	257	1,433	2,961	4,797	4,308	3,788	1,805	220	744	3,866	1,665	3,584	1,760	1,955	1,369	509	1,158	379	137	70	..	..
1941–42	2,369	29	116	1,074	1,605	2,771	2,280	2,509	1,257	167	582	2,972	1,290	3,052	1,203	1,534	1,093	309	890	451	133	69	..	..
1942–43	2,462	29	190	1,304	2,090	3,543	2,792	2,937	1,702	193	670	3,970	1,156	3,626	1,511	1,816	1,309	358	1,141	507	150	64	..	..
1943–44	2,623	72	279	1,499	2,568	3,648	2,187	2,387	1,590	176	728	4,639	1,384	3,810	1,554	1,882	1,491	511	1,487	702	177	91	..	..
1944–45	2,501	46	430	1,741	3,256	5,090	3,669	3,920	1,951	94	695	4,828	1,784	4,005	1,735	1,822	1,583	644	1,751	1,015	228	109	..	..
1945–46	2,498	64	296	1,667	2,634	5,486	4,336	4,152	2,210	150	572	3,841	1,772	3,745	1,694	1,935	1,447	437	1,483	973	213	50	..	..
1946–47	2,717	40	250	1,560	2,332	5,468	3,690	3,933	2,067	170	520	4,216	1,809	3,919	1,910	2,075	1,603	476	1,413	779	212	55	..	..
1947–48	2,356	72	806	1,579	1,825	4,966	3,559	4,528	2,233	122	449	4,026	1,863	3,954	2,425	2,297	1,450	439	1,404	601	169	45	..	..
1948–49	2,143	46	297	1,220	1,573	2,671	3,242	3,727	1,821	82	418	4,306	2,037	4,078	2,436	2,311	1,930	452	1,446	630	71	49	..	..
1949–50	2,829	56	235	1,550	2,050	4,180	3,210	3,705	1,892	120	419	4,000	1,947	3,380	2,260	2,291	1,857	450	1,409	412	100	70	..	..

APPENDIX XXXV.

Gingelly (in 00 acres).

Year.	Visakhapatnam.	East Godavari.	West Godavari.	Kistna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1921–22 ..	1,082	395		812	9	48	150	323	58	38	249	505
1922–23 ..	1,164	538		782	9	19	185	71	41	25	329	417
1923–24 ..	1,399	775		660	6	22	102	174	63	33	170	487
1924–25 ..	1,412	759	650	119	10	34	162	285	31	42	284	411
1925–26 ..	1,454	811	808	91	6	28	107	95	56	39	328	388
1926–27 ..	1,329	808	497	77	9	25	155	298	66	41	142	252
1927–28 ..	1,312	776	596	128	14	36	273	408	82	52	296	503
1928–29 ..	1,378	833	605	93	11	17	184	282	66	47	171	396
1929–30 ..	1,408	664	715	116	14	28	148	93	55	53	154	450
1930–31 ..	1,529	764	582	90	11	20	75	190	46	43	230	398
1931–32 ..	1,461	737	633	98	11	21	198	274	49	34	250	318
1932–33 ..	1,351	838	776	81	11	21	178	375	40	61	296	319
1933–34 ..	1,428	893	692	78	10	25	116	291	31	35	173	558
1934–35 ..	1,272	708	614	69	11	18	71	255	42	48	178	478
1935–36 ..	1,305	767	680	89	17	28	161	295	70	93	267	618
1936–37 ..	1,675	934	680	73	16	18	184	361	64	73	363	538
1937–38 ..	1,588	648	494	40	16	23	81	302	58	67	325	477
1938–39 ..	1,494	885	713	69	21	20	142	390	65	91	146	479
1939–40 ..	1,110	618	498	50	17	27	126	414	82	85	269	414
1940–41 ..	1,208	697	532	36	14	37	97	297	39	37	203	655
1941–42 ..	1,358	729	588	54	18	20	146	222	43	32	132	426
1942–43 ..	1,380	667	673	31	18	17	176	365	55	37	161	790
1943–44 ..	1,356	618	726	61	17	15	166	252	29	90	191	543
1944–45 ..	1,183	819	601	44	20	17	160	409	49	43	158	362
1945–46 ..	1,202	719	639	46	22	15	187	405	40	35	169	240
1946–47 ..	1,086	786	687	48	23	13	252	369	41	140	222	390
1947–48 ..	1,022	760	768	66	25	11	157	299	45	53	247	439
1948–49 ..	1,089	668	636	69	26	16	144	302	93	56	157	397

Year.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22 ..	49	259	528	475	500	239	355	288	583	118	30	
1922–23 ..	40	499	508	248	396	215	277	266	496	120	31	..
1923–24 ..	53	183	353	162	481	243	267	226	516	127	30	..
1924–25 ..	50	345	613	290	424	221	221	242	426	117	29	..
1925–26 ..	55	318	576	240	406	213	224	258	565	116	27	..
1926–27 ..	44	74	295	309	455	230	225	281	646	119	27	..
1927–28 ..	46	206	593	549	521	254	333	226	559	110	26	..
1928–29 ..	46	115	494	360	468	273	248	263	572	705	27	..
1929–30 ..	48	150	594	525	536	253	246	237	654	107	27	..
1930–31 ..	38	254	505	445	444	289	226	228	449	100	26	..
1931–32 ..	64	262	427	257	594	215	260	281	530	101	27	..
1932–33 ..	73	376	561	395	768	245	312	221	503	90	26	..
1933–34 ..	59	253	523	363	736	231	271	273	694	84	26	..
1934–35 ..	60	206	558	188	395	185	128	215	321	69	27	..
1935–36 ..	61	165	410	250	660	215	206	299	507	83	26	..
1936–37 ..	71	237	403	267	588	260	227	285	582	98	23	..
1937–38 ..	68	350	702	567	617	178	300	311	614	99	25	..
1938–39 ..	57	129	659	476	873	270	406	332	917	105	24	..
1939–40 ..	58	369	1,150	565	678	90	295	259	118	87	26	..
1940–41 ..	46	305	825	610	771	187	296	242	664	84	26	..
1941–42 ..	35	100	647	530	918	104	306	230	185	92	25	..
1942–43 ..	39	194	913	615	995	134	251	259	514	89	25	..
1943–44 ..	53	105	615	561	608	145	130	225	360	77	26	..
1944–45 ..	34	89	300	209	710	137	224	207	210	50	27	..
1945–46 ..	45	122	361	232	607	127	247	182	256	65	27	..
1946–47 ..	49	156	438	300	718	192	235	143	396	69	26	..
1947–48 ..	36	124	338	371	774	154	297	156	243	59	27	..
1948–49 ..	38	95	528	360	785	141	262	116	195	45	27	..

APPENDIX XXXVI.

Castor (in 00 acres).

Year.	Vizakhapatnam.	East Godavari.	West Godavari.	Kistna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22 ..	36		8	157	487	362	233	775	193	412	2	12	160	68	201	155	124	3	120	20	16	4	3	..
1922–23 ..	34		11	162	507	394	188	576	136	298	1	8	147	48	196	135	95	2	75	22	15	6	2	..
1923–24 ..	151		68	293	442	388	243	628	106	358	..	6	92	54	199	92	89	4	70	22	9	4	2	..
1924–25 ..	189	98	162	189	525	317	211	627	119	458	..	9	101	55	196	113	86	18	60	21	9	5	2	..
1925–26 ..	126	91	113	169	559	450	191	641	161	532	..	8	101	60	205	99	84	5	60	23	8	4	2	..
1926–27 ..	119	78	111	140	617	445	245	849	124	430	..	8	106	53	189	94	88	4	74	18	8	3	2	..
1927–28 ..	115	77	101	115	531	379	203	815	118	507	..	8	75	44	183	98	84	4	58	17	7	3	2	..
1928–29 ..	121	74	88	127	477	368	211	780	107	507	..	5	61	35	193	83	77	4	46	14	9	4	2	..
1929–30 ..	120	74	89	99	306	259	143	337	61	455	1	7	39	42	204	106	88	4	50	17	11	4	2	..
1930–31 ..	108	67	84	104	259	272	173	666	126	329	..	9	65	47	204	110	83	3	47	15	8	2	2	..
1931–32 ..	102	74	94	105	359	324	287	716	148	422	..	16	85	50	225	83	79	4	49	18	7	2	2	..
1932–33 ..	104	81	76	115	366	330	236	820	130	520	..	10	96	53	238	120	104	3	69	15	8	2	2	..
1933–34 ..	102	79	64	87	319	314	159	693	86	476	..	11	56	51	239	99	81	5	46	11	10	3	2	..
1934–35 ..	102	90	67	73	332	355	145	640	122	312	1	11	66	55	173	65	64	3	31	8	10	5	2	..
1935–36 ..	13	66	58	52	311	312	162	602	88	364	..	10	56	49	177	63	80	4	27	10	11	4	2	..
1936–37 ..	13	77	34	39	296	285	227	672	78	388	..	7	46	52	199	73	85	4	32	13	13	4	2	..
1937–38 ..	9	88	40	38	288	290	137	592	78	399	..	7	36	52	206	80	79	3	24	8	12	3	2	..
1938–39 ..	11	68	38	30	285	278	178	685	111	462	..	36	48	58	206	71	93	4	23	7	11	4	2	..
1939–40 ..	15	62	42	23	273	299	176	791	111	384	..	8	53	44	180	69	74	3	20	8	9	4	2	..
1940–41 ..	22	78	39	33	285	325	213	696	123	349	..	8	51	51	197	80	66	7	18	9,	10	4	2	..
1941–42 ..	18	64	31	29	240	299	176	617	87	372	..	8	40	54	209	71	71	2	21	10	9	3	2	..
1942–43 ..	22	22	91	39	290	330	245	702	102	413	..	10	50	61	200	74	72	2	19	9	10	4	2	..
1943–44 ..	18	23	98	37	328	230	250	670	71	498	..	11	48	62	196	68	71	2	19	8	10	4	3	..
1944–45 ..	36	12	69	27	257	419	274	780	86	435	..	9	35	50	188	57	60	2	15	10	7	5	3	..
1945–46 ..	11	10	54	19	255	301	190	611	68	392	1	9	38	48	187	58	64	4	15	5	6	5	2	..
1946–47 ..	15	21	63	17	224	315	194	546	68	424	..	7	32	42	188	54	59	2	11	6	5	4	3	..
1947–48 ..	17	18	58	17	243	383	179	590	88	460	..	6	37	38	187	53	55	1	12	5	5	3	3	..
1948–49 ..	21	19	67	24	272	350	146	509	62	433	..	6	32	36	169	70	53	1	12	7	4	3	3	..

APPENDIX XXXVII.

Coconuts (in 00 acres).

Year,	Vizakhapatnam.	East Godavari.	West Godavari.	Krishna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1921–22 ..	33	490		93	7	1	23	9	2	3	55	39
1922–23 ..	27	499		92	9	1	23	6	2	3	68	36
1923–24 ..	23	226		92	7	1	22	6	1	4	60	34
1924–25 ..	38	237	94	8	2	1	21	5	1	3	89	34
1925–26 ..	37	594	96	7	8	..	27	5	2	2	93	35
1926–27 ..	32	519	97	10	4	..	21	5	1	5	86	34
1927–28 ..	35	508	96	12	2	..	21	5	1	5	90	32
1928–29 ..	27	526	90	10	2	..	20	5	3	2	90	35
1929–30 ..	29	506	90	10	2	..	19	4	3	58	49	37
1930–31 ..	32	540	89	10	2	..	18	5	1	4	58	34
1931–32 ..	27	521	95	10	2	1	18	5	1	3	56	47
1932–33 ..	27	530	92	10	2	1	18	5	2	3	28	43
1933–34 ..	23	526	100	12	2	..	17	5	1	3	58	41
1934–35 ..	22	531	93	8	2	1	17	5	1	3	66	39
1935–36 ..	100	529	95	8	2	1	17	5	1	3	71	35
1936–37 ..	112	527	94	8	2	1	17	4	1	3	67	31
1937–38 ..	113	543	97	4	2	..	17	4	1	3	66	38
1938–39 ..	107	535	97	7	2	1	17	5	1	3	63	21
1939–40 ..	113	534	98	10	2	..	16	4	1	3	69	39
1940–41 ..	105	547	99	11	2	..	17	5	1	2	71	38
1941–42 ..	109	527	98	10	2	1	17	5	1	3	65	37
1942–43 ..	111	540	103	11	1	1	17	4	1	3	62	37
1943–44 ..	140	563	102	12	1	1	16	4	1	3	65	34
1944–45 ..	133	563	105	11	1	1	16	4	1	3	69	34
1945–46 ..	149	566	102	11	1	1	16	4	2	3	53	35
1946–47 ..	109	559	99	5	1	..	15	9	2	3	66	34
1947–48 ..	121	556	121	12	1	..	14	4	1	4	59	34
1948–49 ..	126	562	111	9	1	1	15	6	1	2	63	33

Year,	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22 ..	25	129	121	74	65	311	73	50	44	3,375	470	..
1922–23 ..	29	105	115	73	67	326	67	54	45	3,211	475	..
1923–24 ..	22	118	93	81	66	315	63	55	44	3,299	477	..
1924–25 ..	23	113	99	79	69	314	69	59	43	3,288	487	..
1925–26 ..	36	116	96	83	64	315	51	30	48	3,386	490	..
1926–27 ..	28	107	92	78	64	346	65	32	46	3,269	492	..
1927–28 ..	25	112	87	89	64	336	61	42	51	3,340	475	..
1928–29 ..	29	106	86	101	64	349	64	36	52	3,439	478	..
1929–30 ..	28	109	87	104	54	350	56	38	53	3,481	479	..
1930–31 ..	25	115	88	100	65	359	71	32	74	3,380	488	..
1931–32 ..	29	113	89	97	65	339	71	46	55	3,125	484	..
1932–33 ..	30	115	91	103	65	346	73	42	54	3,321	484	..
1933–34 ..	29	115	91	105	65	323	72	63	53	3,353	472	..
1934–35 ..	31	115	90	108	65	364	77	36	59	3,486	474	..
1935–36 ..	30	117	94	110	64	372	76	43	51	3,532	471	..
1936–37 ..	29	120	94	112	64	374	80	45	52	3,538	471	..
1937–38 ..	30	122	93	112	63	365	79	89	55	3,531	481	..
1938–39 ..	33	124	97	114	64	350	79	87	54	3,505	490	..
1939–40 ..	24	115	193	114	63	377	83	86	57	3,602	481	..
1940–41 ..	28	124	96	116	62	363	81	91	51	3,593	482	..
1941–42 ..	28	118	91	118	64	368	84	54	49	3,642	472	..
1942–43 ..	27	120	93	115	63	357	81	56	48	3,634	486	..
1943–44 ..	24	118	91	118	63	358	79	66	50	3,655	491	..
1944–45 ..	25	115	94	119	62	366	84	63	47	3,728	508	..
1945–46 ..	24	119	99	118	64	354	84	63	49	3,696	529	..
1946–47 ..	22	115	97	112	62	372	83	58	51	3,778	532	..
1947–48 ..	21	129	95	119	63	390	83	49	50	3,714	540	..
1948–49 ..	24	118	95	122	80	376	83	43	51	3,760	545	..

APPENDIX XXXVIII.

Other oil seeds (in 00 acres).

Year.	Visakhapatnam.	East Godavari.	West Godavari.	Krishna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22 ..	6	4		3	6	46	178	118	64	2	3	11	95	13	5	10	17	62	2	2	2	8	1	..
1922–23 ..	6	[illegible]		1	6	79	216	111	56	1	2	20	93	13	12	2	16	60	1	2	2	8	1	..
1923–24 ..	926	268		6	6	48	89	103	19	..	32	25	89	9	17	1	16	61	1	1	2	5	1	..
1924–25 ..	916	4	1	3	8	42	126	129	41	2	18	26	90	13	16	4	15	48	50	4	9	6	..	..
1925–26 ..	900	4	..	1	6	74	196	130	55	2	10	19	82	24	11	2	15	60	4	1	1	5	1	..
1926–27 ..	959	5	..	8	6	81	140	125	6	2	7	24	83	21	11	1	14	73	1	6	1	4	1	1
1927–28 ..	947	..	..	9	7	86	99	146	33	1	7	52	80	28	13	6	14	75	3	2	1	5	1	..
1928–29 ..	943	..	..	5	6	38	108	129	15	1	8	23	86	19	10	1	14	72	2	4	1	5	1	..
1929–30 ..	949	..	..	8	7	38	250	111	34	1	5	20	76	15	11	4	16	70	1	2	1	7	1	..
1930–31 ..	910	..	..	2	6	45	154	137	30	1	5	23	58	17	7	5	16	69	1	2	1	12	1	..
1931–32 ..	869	1	..	18	23	58	172	172	46	1	6	26	73	24	9	7	14	70	1	4	2	5	1	1
1932–33 ..	869	1	2	4	36	120	149	84	6	7	24	47	32	10	7	14	72	1	2	1	10	1	..	..
1933–34 ..	871	1	2	1	4	45	189	136	38	2	8	17	68	25	18	8	16	78	2	2	2	10	1	1
1934–35 ..	869	1	..	..	7	67	371	179	53	2	9	15	84	19	19	6	15	72	1	1	1	4	1	..
1935–36 ..	18	..	..	2	5	30	189	133	14	2	11	31	83	23	16	5	15	62	1	3	2	1	1	..
1936–37 ..	3	1	..	8	8	40	270	158	52	3	6	20	80	9	18	9	13	60	1	1	2	1	1	..
1937–38 ..	4	2	..	3	7	18	233	130	53	2	9	21	79	14	13	11	14	58	3	..	2	3	1	1
1938–39 ..	5	..	..	2	5	16	270	131	6	10	9	1	69	14	14	10	14	59	2	..	2	1	1	1
1939–40 ..	3	..	1	1	5	19	209	117	44	1	7	13	67	10	18	10	14	61	1	..	2	1	1	..
1940–41 ..	3	..	1	1	5	20	174	131	39	2	15	12	74	11	18	10	13	57	10	..	1	4	1	1
1941–42 ..	11	8	..	3	8	26	195	146	13	2	7	11	76	13	20	10	12	59	1	..	1	..	1	1
1942–43 ..	4	1	..	8	5	12	87	60	9	3	8	15	79	12	21	12	12	62	1	..	1	..	1	1
1943–44 ..	264	..	..	3	4	29	168	128	23	2	8	14	70	8	22	13	13	59	1	..	1	..	1	1
1944–45 ..	258	1	..	3	3	51	183	135	30	1	3	16	91	9	20	11	11	72	1	..	1	1	1	1
1945–46 ..	251	..	..	..	4	25	123	124	20	3	5	10	94	8	15	10	11	56	2	..	1	..	1	..
1946–47 ..	4	1	..	1	7	66	145	109	31	3	8	15	79	7	15	8	11	78	..	2	1	9	1	..
1947–48 ..	125	..	..	7	4	89	161	106	24	13	7	11	64	6	65	9	11	73	..	2	1	9	1	..
1948–49 ..	9	1	..	1	6	42	177	99	29	2	6	6	64	21	16	10	11	56	1	4	1	52	1	..

APPENDIX XXXIX.

Cotton (irrigated and unirrigated) (in 00 acres).

Year. (1)	Visakhapatnam. (2)	East Godavari. (3)	West Godavari. (4)	Krishna. (5)	Guntur. (6)	Kurnool. (7)	Bellary. (8)	Anantapur. (9)	Cuddapah. (10)	Nellore. (11) V	Chingleput. (12)	South Arcot. (13)	Chittoor. (14)	North Arcot. (15)	Salem. (16)	Coimbatore. (17)	Tiruchirappalli. (18)	Tanjore. (19)	Madurai. (20)	Ramanathapuram. (21)	Tirunelveli. (22)	Malabar. (23)	South Kanara. (24)	The Nilgiris. (25)
1921-22	197	63		363	1,090	2,598	2,853	847	605	245	..	9	6	6	173	2,218	268	10	954	2,541	2,721	7	2	..
1922-23	197	68		403	1,349	3,033	5,361	1,371	689	260	..	14	4	11	186	2,828	386	9	1,577	2,687	2,741	4	2	..
1923-24	236	126		554	1,433	3,429	5,541	1,715	1,002	369	..	38	8	28	837	3,291	520	12	1,870	2,808	2,968	4	2	..
1924-25	199	185	18	645	1,509	3,752	6,025	1,820	1,223	362	1	37	18	81	696	3,545	659	13	2,065	2,748	3,073	10	2	..
1925-26	201	183	18	630	1,582	3,220	6,533	2 163	859	4,150	..	23	11	55	680	3,020	711	16	2,092	2,560	3,916	8	2	..
1926-27	194	96	13	416	1,087	2,243	5,228	1,756	573	312	..	8	4	19	497	2,826	474	10	1,487	2,068	2,708	4	2	..
1927-28	191	78	12	432	970	2,072	4,776	1,257	414	460	..	9	1	8	428	2,942	410	9	1,369	2,326	2,810	6	2	..
1928-29	188	112	11	485	1,195	2,319	5,970	1,365	478	387	..	18	2	9	546	3,598	582	11	2,067	2,462	2,823	3	2	..
1929-30	164	107	10	502	228	2,601	5,312	1,441	768	486	..	29	2	12	690	3,640	588	9	1,913	2,489	2,756	3	2	..
1930-31	165	83	12	332	766	2,171	4,797	1,251	696	341	..	24	1	9	408	2,891	379	3	1,376	2,108	2,483	3	2	..
1931-32	170	66	10	299	887	2,097	6,115	1,395	480	317	..	11	..	4	483	3,213	384	2	1,430	2,078	2,583	6	2	..
1932-33	145	58	8	267	834	1,452	4,534	989	300	386	..	12	..	4	649	3,258	430	1	1,299	2,121	2,716	8	2	..
1933-34	137	71	8	176	734	1,776	5,698	1,071	387	347	..	14	..	4	518	3,517	455	1	1,458	2,223	2,957	2	2	..
1934-35	134	116	8	242	831	2.331	4,458	1,190	617	325	..	36	1	11	807	3,989	621	5	2,091	2,332	2,883	3	2	..
1935-36	114	113	7	177	854	2,875	6,465	1,668	930	853	..	76	..	12	961	3,719	625	1	2,018	2,542	3,124	4	2	..
1936-37	101	140	6	150	876	2,332	5,919	1,433	614	306	..	106	1	13	978	3,839	609	2	2,063	2,407	2,946	5	2	..
1937-38	67	105	8	75	781	2,076	6 021	1,551	623	334	..	104	1	18	1,038	4,212	617	..	2,114	2,498	3,146	3	6	..
1938-39	98	100	7	49	690	1,985	5,245	1,145	545	350	..	75	1	9	604	2,225	305	1	1,295	2,104	2,564	4	2	..
1939-40	114	77	5	54	560	2,171	5,454	1,282	574	319	1	109	2	10	674	3,883	301	1	1,518	2,833	2,904	21	2	..
1940-41	109	83	4	101	604	2,078	5,024	1,405	700	311	2	122	4	12	916	4,298	414	2	2,050	2,122	2,845	20	2	..
1941-42	85	64	5	85	659	1,941	5,756	1,622	774	295	2	253	5	24	1,100	4,685	505	2	2,340	2,202	2,979	24	2	..
1942-43	97	57	4	57	628	2,083	4,638	1,367	745	310	2	139	8	16	980	3,889	430	1	1,974	2,076	2,611	38	2	..
1943-44	79	72	6	58	618	1,777	5,342	1,118	612	359	2	123	2	9	807	3,691	477	1	1,875	2,019	2,790	35	2	..
1944-45	61	47	2	25	476	1,190	4,059	1,281	435	307	1	38	1	5	442	2,417	303	..	1,274	1,868	2,436	29	2	..
1945-46	45	29	2	17	465	870	3,824	809	353	290	..	22	..	3	436	2,963	311	1	1,462	1,597	2,594	16	2	..
1946-47	50	47	3	19	465	946	3,979	881	348	325	..	34	..	2	372	2,759	272	..	1,321	1,522	2,314	19	2	..
1947-48	47	30	2	4	366	709	4,197	810	233	273	..	62	..	..	197	1,635	147	..	849	1,379	2,028	6	2	..
1948-49	40	35	1	4	336	1,502	5,123	1,106	308	228	..	49	..	2	238	2,384	215	..	976	1,559	2,162	2	2	..

APPENDIX XL.

Other fibres (in 00 acres).

Year.		Vizakhapatnam.	East Godavari.	West Godavari.	Krishna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22	..	414	115		416	498	3	14	..	8	22	7	2	2	8	8	21	4	1	7	..	4	6	4	..
1922–23	..	415	146		257	647	4	19	17	4	25	11	5	3	2	9	3	4	2	1	..	3	1	4	..
1923–24	..	438	144		379	648	6	24	17	2	23	5	1	2	2	9	4	1	1	2	..	4	2	5	..
1924–25	..	513	230	64	410	693	4	3	18	3	36	10	1	1	1	6	4	1	8	5	..	4	2	4	..
1925–26	..	543	226	30	741	786	3	3	19	1	26	10	1	1	2	6	5	2	2	3	..	4	2	3	..
1926–27	..	532	255	29	143	731	5	26	20	2	26	9	2	1	1	6	5	2	1	2	..	4	2	4	..
1927–28	..	557	182	15	288	561	5	2	17	3	19	10	2	2	4	5	6	2	6	8	1	4	2	4	..
1928–29	..	540	168	13	288	624	7	24	2	7	23	5	3	1	2	7	7	8	1	6	..	8	2	4	..
1929–30	..	555	129	88	189	625	10	2	2	5	15	9	2	1	3	6	10	2	8	1	..	3	1	3	..
1930–31	..	579	208	87	118	584	9	4	2	5	25	9	26	1	4	8	8	2	3	7	..	3	..	5	..
1931–32	..	521	196	67	895	189	9	3	1	4	21	11	4	1	3	10	22	3	3	7	..	3	1	5	..
1932–33	..	498	207	55	390	490	16	7	1	6	22	14	26	..	3	11	14	8	12	1	..	..	2	5	..
1933–34	..	489	215	90	263	489	17	2	20	16	22	11	10	1	2	23	14	8	4	3	..	3	2	5	..
1934–35	..	448	239	66	167	252	15	8	18	8	21	7	9	1	8	8	18	4	3	2	..	3	1	5	..
1935–36	..	363	232	49	176	856	19	10	18	10	28	8	7	1	4	7	5	4	2	1	..	3	2	5	..
1936–37	..	292	289	46	213	615	17	3	19	7	20	16	10	2	5	10	7	4	5	2	..	3	1	5	..
1937–38	..	328	224	60	477	1,110	18	32	18	11	21	12	7	2	5	6	15	5	1	10	..	5	1	5	..
1938–39	..	257	205	28	314	1,202	22	54	18	16	25	13	7	1	5	7	91	5	7	8	..	3	1	6	..
1939–40	..	242	231	46	277	1,181	25	39	18	13	26	14	5	2	5	8	83	5	6	1	..	2	1	6	..
1940–41	..	300	254	28	177	983	23	42	19	9	27	12	15	1	6	9	80	5	15	2	..	4	1	6	..
1941–42	..	224	288	26	368	1,335	22	52	19	5	26	11	8	1	5	11	111	7	8	7	..	6	1	5	..
1942–43	..	198	267	48	171	1,436	20	59	20	8	50	13	11	1	6	9	194	4	5	2	..	6	1	5	..
1943–44	..	213	379	83	223	1,073	17	44	19	6	37	6	22	2	5	10	188	4	5	2	1	6	1	5	..
1944–45	..	186	323	80	311	855	12	45	19	8	33	8	15	2	6	9	200	3	2	10	..	3	1	6	..
1945–46	..	183	300	33	158	1,298	16	33	22	5	32	8	32	..	6	9	28	2	15	10	1	4	1	6	..
1946–47	..	146	209	24	470	523	11	42	19	3	28	8	15	..	5	11	26	2	8	..	..	4	1	6	..
1947–48	..	236	119	20	171	388	19	52	18	3	41	6	22	..	6	11	41	3	7	5	3	9	1	6	..
1948–49	..	408	150	27	429	678	20	41	7	5	34	6	19	1	6	10	29	2	2	2	18	4	2	4	..

APPENDIX XLI.

Indigo (in 00 acres).

Year.	Visakhapatnam.	East Godavari.	West Godavari.	Krishna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	anjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22	8	11		164	516	107	4	44	338	289	73	232	110	42	13	..	15	..	1	..	1	..	..	..
1922–23	8	11		147	823	100	5	3	129	225	68	194	116	42	22	..	16	..	..	1	1	..	..	..
1923–24	5	7		118	144	55	2	3	82	130	45	155	104	35	16	..	5	2	..	1	1	..	..	..
1924–25	5	10	..	68	113	21	..	2	44	176	22	88	104	21	16	..	6	1	..	2	2	..	..	..
1925–26	5	10	..	52	64	23	..	10	85	201	30	121	124	28	12	..	6	2	..	2	1	..	..	..
1926–27	2	6	..	19	19	37	1	11	86	88	25	97	110	22	8	..	3	1	..	1	2	..	..	..
1927–28	2	4	..	9	12	33	..	3	43	86	10	55	86	28	9	..	5	1	2	8	3	..	..	..
1928–29	..	4	..	15	11	34	1	2	72	100	22	76	97	27	6	..	8	1	1	9	1	..	..	..
1929–30	..	4	..	19	13	26	..	1	42	107	34	110	97	50	7	..	3	2	1	8	2	..	..	..
1930–31	..	3	..	5	3	40	..	2	73	89	26	93	83	37	8	..	1	1	1	..	3	..	..	..
1931–32	..	2	..	4	5	22	..	1	49	57	19	72	88	37	10	..	1	1	1	..	3	..	..	..
1932–33	..	2	1	8	5	33	..	..	97	97	23	79	40	51	12	..	3	1	1	1	6	..	..	..
1933–34	..	2	..	7	9	39	..	4	37	38	13	65	35	34	9	..	5	..	1	1	2	..	..	..
1934–35	..	2	..	18	46	49	..	16	178	67	18	72	32	31	12	..	8	1	1	..	1	..	..	..
1935–36	..	3	..	6	5	20	..	5	40	36	16	63	24	29	8	..	6	1	1	..	2	..	..	..
1936–37	..	2	1	6	3	13	..	1	70	38	16	61	29	36	9	..	8	..	..	..	2	..	..	..
1937–38	..	2	..	3	3	11	..	4	46	54	14	34	24	25	5	..	3	..	..	..	1	..	..	..
1938–39	..	1	..	2	4	16	..	4	60	69	15	65	10	27	6	..	4	..	..	2	2	..	..	..
1939–40	..	2	..	2	4	21	..	6	33	102	12	45	20	38	9	..	6	..	..	..	2	..	..	..
1940–41	..	2	..	4	8	66	..	14	123	155	10	70	26	45	8	..	6	..	..	1	1	..	..	..
1941–42	..	3	..	8	5	28	..	10	50	122	12	77	20	39	7	..	3	..	..	5	..	..	..	..
1942–43	..	2	..	4	6	28	..	5	61	118	19	72	21	63	7	..	2	1	..	1	..	..	..	..
1943–44	..	2	4	4	10	12	..	7	107	127	12	58	18	16	7	..	2	..	..	5	..	..	..	..
1944–45	..	1	..	5	15	10	3	21	104	186	10	69	19	26	4	..	1	2	..	..	..	..	..	..
1945–46	..	2	..	6	16	83	15	27	113	94	6	70	17	12	1	..	1	..	..	8	..	..	..	..
1946–47	..	3	..	5	12	16	1	5	22	69	6	67	11	23	3	..	1	..	2	21	3	..	..	..
1947–48	3	1	..	6	4	5	..	8	81	57	5	70	10	10	4	..	1	..	..	11	3	..	..	..
1948–49	1	1	..	3	3	6	..	1	21	37	5	46	14	21	5	..	1	..	..	7	2	..	..	..

APPENDIX XLII.

Other Dyes (actual acreage).

Year.	Visakhapatnam.	East Godavari.	West Godavari.	Krishna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirapalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22 ..	..	4	4	26	19	725	107	12	..	18	68	..	12	281	77	..	23	47	18	..	233	..	..	..
1922–23 ..	..	..	..	27	21	1,659	..	1,823	..	.	81	11	3	127	130	..	5	22	8	..	180	..	..	..
1923–24 ..	250	4	4	26	21	..	..	1,617	..	..	82	4	3	67	71	..	16	5	21	1	5,551	..	..	..
1924–25 ..	250	5	27	..	20	..	322	..	1	2	76	..	76	102	178	..	12	2	2	7	431	..	..	..
1925–26 ..	250	..	24	..	32	..	270	..	..	18	10	..	..	162	41	..	7	88	15	..	1,316	..	..	..
1926–27 ..	3,817	5	27	..	..	..	180	..	..	3	16	..	1	149	57	..	12	81	4	..	..	..	..	..
1927–28 ..	3,363	..	29	..	..	..	172	..	2	..	34	..	6	67	11	..	5	83	2	..	..	..	..	..
1928–29 ..	3,255	..	29	..	14	..	1,156	..	..	.	9	..	2	76	63	..	6	82	..	..	1,018	..	..	200
1929–30 ..	3,374	..	37	..	2	..	2,456	1,764	..	2	6	..	..	220	28	..	..	96	1	7	1,909	..	..	200
1930–31 ..	3,270	..	35	..	..	..	316	..	..	1	39	..	..	137	3	..	52	99	32	95	994	..	..	200
1931–32 ..	800	..	32	..	22	..	1,924	..	..	..	6	..	..	54	67	..	47	92	..	..	1,183	..	..	250
1932–33 ..	800	..	30	..	23	..	1,793	..	..	..	8	..	..	82	152	..	3	89	7	..	1,901	..	..	250
1933–34 ..	750	7	36	..	4	..	17	..	..	1	8	132	..	45	97	..	10	90	745	..	1,015	..	..	..
1934–35 ..	725	8	32	..	..	..	21	..	..	..	7	64	..	75	225	..	5	78	..	..	597	..	..	..
1935–36 ..	..	15	35	8	8	..	21	..	..	..	7	10	82	72	140	..	29	99	3	466	327	..	..	..
1936–37 ..	120	8	36	19	8	..	201	..	..	..	7	10	..	114	167	1	37	102	11	..	66	..	..	..
1937–38 ..	120	19	37	..	21	..	90	..	..	..	8	9	25	141	122	..	33	162	107	82	329	..	..	..
1938–39 ..	..	33	38	..	39	..	282	..	..	..	79	115	..	82	79	..	14	99	417	40	341	..	..	..
1939–40 ..	120	25	38	..	5	..	171	..	8	..	12	281	..	253	102	..	18	132	8	131	377	..	..	..
1940–41 ..	..	25	33	..	26	..	198	..	29	..	11	248	..	198	98	..	..	478	4	82	394	..	..	..
1941–42 ..	..	41	34	..	..	..	..	..	..	24	10	1,673	8	175	65	..	..	1	2	170	912	..	..	..
1942–43 ..	2	18	31	..	..	108	..	3	..	801	6	107	7	48	44	..	..	428	6	42	789	..	..	..
1943–44 ..	..	10	32	..	2	..	189	..	..	4	17	3	21	97	105	..	..	12	5	6	211	..	..	..
1944–45 ..	44	12	30	..	4	..	257	..	..	200	11	1,394	..	47	546	..	..	57	..	314	129	..	..	1,369
1945–46 ..	120	..	21	..	..	..	210	40	..	..	485	85	..	80	140	..	..	..	..	29	38	..	..	1,378
1946–47 ..	..	7	18	..	..	..	197	..	..	6	7	427	..	199	137	..	..	1	..	7	997	..	..	1,328
1947–48 ..	185	5	20	1	11	..	216	..	..	17	6	704	5	41	326	..	..	..	..	19	346	..	..	1,320
1948–49 ..	138	..	22	..	..	..	184	..	..	1	..	511	1	39	284	..	..	41	18	48	173	..	..	1,858

APPENDIX XLIII.

Tobacco (in 00 acres).

Year.	Vizakhapatnam.	East Godavari.	West Godavari.	Krishna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirapalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22 ..	242	91	91	120	385	112	20	27	16	24	1	24	7	30	58	346	49	20	133	31	10	..	17	..
1922–23 ..	268	78	78	116	608	71	27	32	14	24	1	22	7	28	43	299	49	19	93	23	10	..	17	..
1923–24 ..	483	116	116	133	645	115	27	48	19	26	..	30	6	22	37	255	40	22	74	39	10	..	16	1
1924–25 ..	507	159	69	99	997	131	31	46	20	30	..	21	5	32	44	217	32	23	36	46	12	..	15	..
1925–26 ..	521	136	68	83	31	41	16	23	1	16	9	32	48	316	47	18	123	58	18	..	15	..	..	..
1926–27 ..	516	113	55	62	663	51	33	35	12	22	..	23	8	41	42	386	46	23	110	28	11	..	15	..
1927–28 ..	519	152	67	86	1,103	104	42	58	17	28	..	19	5	18	42	269	38	22	89	30	13	..	14	1
1928–29 ..	515	163	75	79	982	71	31	45	18	28	..	18	6	19	36	263	26	19	82	26	10	..	14	..
1929–30 ..	524	121	65	57	1,006	41	25	22	9	26	..	17	5	22	49	334	34	16	107	28	13	..	14	..
1930–31 ..	529	116	61	56	653	95	39	39	26	26	..	23	6	27	42	413	50	22	119	32	14	..	13	..
1931–32 ..	511	139	77	69	972	123	64	79	25	29	..	18	8	24	43	313	36	18	64	19	8	1	15	..
1932–33 ..	506	167	92	79	1,112	15	11	7	9	29	1	16	4	17	34	278	32	17	63	14	7	1	16	..
1933–34 ..	511	162	79	61	948	46	10	14	17	27	..	17	5	21	49	296	43	15	77	21	11	..	16	..
1934–35 ..	502	159	72	74	1,190	134	26	36	20	27	..	20	5	22	43	337	49	20	97	29	11	..	18	..
1935–36 ..	299	165	88	106	1,336	89	35	28	14	27	..	18	5	18	40	328	49	17	85	18	9	1	19	..
1936–37 ..	335	195	93	86	1,283	45	23	25	10	27	..	17	4	21	49	232	32	14	54	12	5	1	17	..
1937–38 ..	315	193	88	136	1,488	66	19	19	18	37	..	17	4	21	60	262	41	15	89	23	12	1	18	..
1938–39 ..	330	194	101	159	1,642	113	22	33	15	47	..	16	5	17	57	268	38	19	80	20	8	..	18	..
1939–40 ..	324	203	97	133	1,463	76	38	36	17	40	..	19	4	21	56	356	47	17	88	13	6	1	18	..
1940–41 ..	312	246	150	185	1,636	45	15	13	13	40	..	18	4	19	46	215	34	14	57	17	6	..	18	..
1941–42 ..	319	253	200	238	1,550	91	23	33	23	31	..	22	5	24	56	286	44	14	84	15	6	..	20	..
1942–43 ..	330	208	189	146	1,265	111	25	41	15	26	..	18	3	14	41	250	38	13	84	16	7	..	21	..
1943–44 ..	176	183	182	162	1,122	25	9	5	10	28	..	20	4	17	46	230	37	12	77	13	7	..	16	..
1944–45 .	189	264	212	192	1,478	95	21	52	27	33	..	23	4	19	64	358	60	18	112	23	12	..	20	..
1945–46 ..	187	286	237	197	1,621	327	56	52	25	31	..	16	5	12	57	401	32	15	85	13	6	..	20	..
1946–47 ..	158	210	222	169	1,840	59	17	13	13	17	..	12	3	13	42	172	14	11	25	5	2	..	20	..
1947–48 ..	149	192	258	189	1,548	31	9	28	9	21	..	20	3	10	48	297	31	13	59	7	3	..	19	..
1948–49 ..	153	265	290	201	1,696	65	16	34	6	21	..	16	3	12	38	283	30	13	49	8	3	..	20	..

APPENDIX XLIV.

Other Drugs and Narcotics.

In 00 acres (including Betelvine, Coffee, Tea, Cinchona and Arecanut).

Year.	Vizakhapatnam.	East Godavari.	West Godavari.	Kistna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirapalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921-22 ..	4	12	12	..	6	155	8	37	9	5	15	5	15	15	115	214	11	19	134	17	81	1,023	178	452
1922-23 ..	4	8	8	..	3	51	7	20	9	6	14	8	14	16	121	219	3	21	132	16	69	923	183	454
1923-24 ..	25	7	7	1	2	81	8	18	10	5	21	8	15	14	115	227	14	21	134	15	32	941	180	455
1924-25 ..	63	6	..	..	8	30	7	16	9	5	20	9	13	12	121	223	12	22	164	17	89	944	180	460
1925-26 ..	60	6	1	..	3	108	6	15	9	6	15	8	11	14	118	251	12	22	127	25	79	958	180	472
1926-27 ..	55	5	..	..	4	40	5	12	7	5	17	9	14	14	117	257	18	23	125	26	71	952	181	482
1927-28 ..	47	5	..	10	3	142	6	12	5	4	14	8	15	14	117	264	13	22	123	33	65	973	180	515
1928-29 ..	54	17	..	..	4	36	6	11	4	6	15	9	16	14	120	280	13	21	125	49	57	983	184	515
1929-30 .	12	5	..	..	4	8	5	10	8	3	14	12	15	17	126	287	13	21	131	44	75	1,005	187	525
1930-31 ..	7	4	..	..	3	46	7	31	11	4	16	12	16	15	133	314	14	23	143	34	56	1,023	185	520
1931-32 ..	47	4	..	..	5	106	6	14	9	5	13	11	16	15	137	332	14	25	148	59	47	1,015	186	545
1932-33 ..	48	4	1	1	5	28	7	15	10	6	14	12	18	16	141	342	14	27	148	76	62	1,065	190	572
1933-34 ..	47	4	..	1	4	18	6	14	10	8	15	12	18	17	142	342	15	27	155	74	80	1,088	193	579
1934-35 ..	48	26	..	..	4	59	6	14	11	6	18	10	18	14	144	354	16	25	161	25	64	1,111	193	592
1935-36 ..	9	10	..	..	8	41	6	14	12	7	17	10	13	16	147	350	17	24	161	80	89	1,103	200	602
1936-37 ..	8	3	..	..	6	32	7	15	10	7	18	10	16	17	148	316	15	23	172	33	105	1,102	203	602
1937-38 ..	9	3	..	..	4	23	7	16	9	7	12	10	17	16	152	316	14	25	174	32	72	1,113	197	598
1938-39 ..	9	2	..	..	6	32	7	16	9	6	13	11	16	15	138	317	16	25	178	23	61	1,121	198	608
1939-40 ..	8	3	..	..	5	70	6	15	11	6	15	12	17	16	144	311	16	25	171	20	64	1,108	192	612
1940-41 ..	10	7	1	..	6	48	6	15	11	8	14	11	22	16	152	323	16	24	228	24	75	1,124	197	619
1941-42 ..	10	2	..	..	7	17	6	19	10	6	9	12	17	14	154	331	15	23	219	37	51	1,182	202	617
1942-43 ..	10	2	1	1	8	39	6	19	9	6	11	11	16	14	161	317	14	25	201	22	46	1,162	201	620
1943-44 ..	5	2	1	1	5	10	5	14	10	5	9	8	14	14	135	332	12	25	211	10	30	1,183	200	626
1944-45 ..	8	1	1	..	8	11	5	14	7	9	7	5	12	11	148	331	12	25	176	14	27	1,217	205	625
1945-46 ..	8	2	10	1	6	30	5	16	10	5	7	9	11	15	151	309	15	25	171	9	32	1,224	219	605
1946-47 ..	7	1	1	2	6	5	5	14	11	6	10	13	11	16	147	316	15	23	149	8	37	1,198	230	632
1947-48 ..	8	2	2	..	2	16	5	14	10	5	9	13	..	15	144	326	14	22	168	8	41	1,198	238	622
1948-49 ..	6	1	1	1	2	47	5	13	9	5	8	11	12	17	145	39	14	21	181	4	27	1,257	240	630

APPENDIX XLV.

Fodder Crops (in 00 acres).

Year.	Vizakhapatnam.	East Godavari.	West Godavari.	Kistna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirapalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921–22 ..	..	159	159	42	1,489	..	..	3	..	..	..	7	3	..	83	..	46	..	22	314	587	2	17	1
1922–23 ..	..	150	150	431	1,693	1	..	1	..	1	1	3	4	..	82	..	2	..	36	294	598	2	16	..
1923–24 ..	159	184	184	462	1,800	..	..	1	..	6	..	2	..	1	85	..	1	..	40	333	612	3	16	1
1924–25 ..	211	210	17	728	1,890	..	..	2	.	21	..	7	..	1	80	..	6	..	10	360	674	1	11	2
1925–26 ..	211	242	20	376	1,719	..	..	..	.	17	..	5	..	..	81	..	..	..	26	366	796	..	12	1
1926–27 ..	237	184	55	1,071	1,866	1	5	1	..	17	..	..	..	..	81	..	1	..	22	342	638	..	10	1
1927–28 ..	211	167	111	1,048	1,776	1	..	..	57	27	1	..	..	2	82	..	1	1	36	320	567	..	10	..
1928–29 ..	187	153	50	826	1,684	1	4	.	2	65	..	..	..	1	82	1	11	..	30	323	631	..	10	1
1929–30 ..	191	152	18	839	1,636	2	5	1	1	72	..	..	..	..	21	..	3	..	12	417	813	1	9	..
1930–31 ..	191	159	183	964	1,635	1	9	4	..	44	..	..	..	..	..	..	1	4	21	476	785	..	20	..
1931–32 ..	190	189	70	619	2,047	7	8	2	..	71	..	4	1	1	..	1	..	7	19	469	930	..	14	..
1932–33 ..	183	175	71	704	1,923	5	..	4	1	157	..	2	..	1	18	3	..	2	14	551	1,021	..	..	..
1933–34 ..	189	263	84	838	1,857	5	12	7	..	170	..	1	..	1	48	9	..	5	13	460	869	..	9	..
1934–35 ..	174	153	83	808	2,061	6	10	8	2	178	.	..	..	1	29	4	..	1	36	484	893	..	10	..
1935–36 ..	..	249	105	708	1,563	8	1	10	6	293	2	13	2	1	29	15	1	..	35	521	1,064	..	8	..
1936–37 ..	..	241	83	857	2,203	9	4	11	6	233	1	1	1	1	32	21	..	..	39	523	1,047	1	11	..
1937–38 ..	1	277	122	497	1,297	10	18	12	7	283	1	..	1	1	40	40	..	..	45	476	990	..	11	..
1938–39 ..	..	165	145	596	1,395	29	2	15	2	315	2	2	8	..	40	10	1	..	38	490	1,058	..	11	..
1939–40 ..	5	289	129	594	1,386	18	2	21	4	334	2	2	1	1	33	79	..	..	53	491	1,085	..	11	..
1940–41 ..	5	157	208	776	1,544	13	2	13	1	284	..	7	1	1	41	30	..	4	68	412	1,020	..	11	..
1941–42 ..	2	208	46	562	1,227	8	3	16	1	279	3	2	2	1	40	93	..	10	68	375	927	..	11	..
1942–43 ..	4	161	77	638	930	11	4	7	..	354	2	6	7	3	42	11	..	7	66	450	937	..	11	..
1943–44 ..	7	206	178	959	989	18	4	11	1	321	4	1	3	1	68	12	..	1	62	525	936	..	11	..
1944–45 ..	11	191	150	894	1,036	11	26	10	1	233	3	1	5	1	64	154	..	8	52	612	1,130	..	..	..
1945–46 ..	35	231	178	946	982	21	5	18	2	311	..	2	6	2	79	25	..	3	89	663	1,086	..	..	..
1946–47 ..	10	221	241	700	1,747	37	3	23	2	333	9	9	12	3	7	112	4	1	107	717	1,329	..	..	..
1947–48 ..	24	148	171	850	1,086	26	2	15	7	240	..	43	9	4	82	34	..	2	119	580	999	..	..	..
1948–49 ..	7	156	151	601	956	22	2	15	10	428	..	1	11	2	85	49	2	3	97	674	1,154	..	..	..

APPENDIX XLVI.

Miscellaneous Non-food Crops (in 00 acres).

Year.	Vizakhapatnam.	East Godavari.	West Godavari.	Kristna.	Guntur.	Kurnool.	Bellary.	Anantapur.	Cuddapah.	Nellore.	Chingleput.	South Arcot.	Chittoor.	North Arcot.	Salem.	Coimbatore.	Tiruchirappalli.	Tanjore.	Madurai.	Ramanathapuram.	Tirunelveli.	Malabar.	South Kanara.	The Nilgiris.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
1921-22 ..	1	1	1	..	8	12	96	99	155	..	157	60	17	182	33	111	17	111	82	78	19	172	2	11
1922-23 ..	..	..	..	1	7	16	99	152	113	37	41	107	20	260	37	123	20	90	45	80	103	145	2	10
1923-24 ..	23	5	5	4	17	5	100	103	17	100	212	13	20	226	16	148	21	97	70	67	114	170	2	11
1924-25 ..	74	5	..	1	42	2	111	144	87	14	217	83	40	195	19	157	15	74	46	27	106	155	2	11
1925-26 ..	60	..	..	8	23	22	98	100	47	13	258	72	19	167	12	138	18	94	52	35	241	192	2	8
1926-27 ..	16	..	..	3	4	20	76	60	122	28	187	113	14	175	17	113	12	142	61	34	210	265	2	8
1927-28 ..	12	..	..	81	9	12	82	27	87	71	179	68	34	192	14	106	12	147	46	10	94	291	2	8
1928-29 ..	14	1	..	1	1	13	48	27	21	58	189	130	56	183	11	101	11	144	52	28	41	238	2	11
1929-30 ..	61	1	42	8	15	3	48	81	67	137	154	169	74	212	14	98	14	118	34	25	190	239	2	12
1930-31 ..	72	..	3	14	42	4	103	24	53	64	237	116	71	175	17	77	16	106	59	83	148	237	2	17
1931-32 ..	22	3	3	..	17	1	71	62	29	59	239	31	29	201	16	43	16	77	62	77	46	248	2	17
1932-33 ..	14	8	..	2	18	1	92	24	82	17	233	52	32	190	15	88	22	104	59	93	114	287	3	23
1933-34 ..	17	5	2	1	7	1	86	23	12	13	275	70	32	195	21	88	18	118	62	36	102	271	3	28
1934-35 ..	14	..	2	1	6	1	69	24	53	20	319	85	31	199	18	75	13	79	45	89	45	332	2	28
1935-36 ..	7	1	3	6	10	2	58	29	36	13	247	33	30	182	15	65	17	67	31	83	40	342	3	26
1936-37 ..	7	11	2	8	13	1	60	32	22	6	266	151	40	192	12	64	17	32	46	86	84	337	3	9
1937-38 ..	6	16	1	4	18	1	18	51	21	4	133	118	29	179	11	92	21	76	38	90	122	382	3	26
1938-39 ..	11	6	2	1	111	12	6	22	26	19	37	226	44	183	10	4	23	41	26	38	95	314	3	45
1939-40 ..	5	18	1	19	19	8	3	26	8	49	40	194	31	176	14	4	30	58	46	33	110	364	3	46
1940-41 ..	5	14	2	6	125	15	2	6	12	23	54	217	37	177	19	20	25	19	40	34	216	342	3	47
1941-42 ..	9	8	..	8	189	4	8	22	84	23	57	50	32	157	38	18	28	50	42	34	208	357	3	46
1942-43 ..	8	3	38	4	159	7	8	31	44	8	66	117	23	63	34	9	30	50	53	32	167	425	3	47
1943-44 ..	14	20	38	3	176	4	29	36	18	8	100	77	29	56	33	8	32	57	44	35	166	452	3	55
1944-45 ..	30	6	1	3	35	4	5	29	18	10	69	66	53	61	41	8	25	31	30	38	166	390	3	50
1945-46 ..	84	9	1	1	25	2	21	36	11	188	82	47	19	56	33	191	26	55	28	33	166	451	95	55
1946-47 ..	36	5	1	1	15	1	6	72	13	57	86	69	22	59	27	217	28	30	30	30	197	655	96	10
1947-48 ..	48	84	22	11	8	4	4	37	15	17	49	68	29	62	41	204	29	92	37	34	162	458	95	9
1948-49 ..	23	15	28	2	17	3	14	49	7	7	68	144	13	61	36	167	278	34	28	27	177	457	92	10

APPENDIX XLVII.

Statement showing the estimated production of Principal Crops in Madras State.

Year.	Paddy (irrigated and unirrigated).	Cholam. (irrigated and unirrigated).	Cumbu. (irrigated and unirrigated).	Ragi.	Korra.	Varagu.	Samai.	Maize.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	TONS.	TONS.	TONS.	TONS.	TONS.	TONS.	TONS.	TONS.
1921–22	7,806,140	1,524,220	825,420	1,154,320	245,670	448,640	154,990	51,590
1922–23	7,808,910	1,438,290	816,180	1,184,800	194,030	400,520	137,350	64,410
1923–24	6,762,610	1,270,700	631,690	1,060,630	249,510	367,140	126,720	62,650
1924–25	7,325,840	1,404,590	833,120	1,131,090	345,080	482,090	148,910	70,780
1925–26	7,943,260	1,291,590	818,910	1,061,270	351,750	427,200	157,480	66,940
1926–27 (Rice)	4,742,000	1,211,280	783,360	1,009,850	222,280	384,460	165,700	38,860
1927–28 (do.)	5,083,000	1,339,400	835,800	1,050,090	332,720	388,450	159,120	67,100
1928–29	7,757,230	1,368,220	829,890	1,069,620	324,220	423,750	163,430	56,500
1929–30	7,700,710	1,482,760	761,060	1,046,130	253,440	401,200	178,830	55,580
1930–31	8,023,240	1,275,420	775,160	1,009,990	318,700	372,110	164,880	63,880
1931–32	8,037,450	1,314,340	779,720	1,014,380	255,270	423,670	150,270	50,380
1932–33	8,068,220	1,290,900	783,670	1,034,440	386,160	440,130	165,200	46,030
1933–34	7,932,010	1,283,270	691,070	1,001,410	267,220	414,570	145,750	46,870
1934–35	7,434,450	1,275,560	627,300	938,030	199,070	345,980	111,450	26,610
1935–36	7,283,840	1,369,780	715,570	833,860	303,640	364,210	94,000	30,120
1936–37	7,155,900	1,301,640	708,980	881,460	208,160	320,080	107,210	34,050
1937–38	7,238,590	1,096,950	662,740	778,190	184,100	308,690	95,300	31,410
1938–39	6,119,740	1,265,300	643,870	699,440	335,520	256,220	81,090	27,120
1939–40	6,667,040	1,387,310	702,540	761,710	302,850	278,250	103,250	31,970
1940–41	7,687,120	1,326,770	712,600	854,220	306,090	340,930	113,300	31,580
1941–42	7,396,000	1,214,070	640,350	823,560	243,780	380,490	131,090	26,970
1942–43	6,886,320	1,098,490	606,350	756,010	181,650	345,290	97,150	25,380
1943–44	7,360,990	1,150,380	688,190	783,520	210,240	308,440	97,320	26,050
1944–45	7,543,250	1,201,430	605,300	742,540	228,250	289,690	97,450	22,220
1945–46	6,390,590	903,820	491,790	606,840	177,170	258,510	74,770	16,110
1946–47	7,342,450	881,370	517,450	659,880	204,990	235,890	72,590	19,200
1947–48	6,462,150	946,310	480,800	582,870	231,620	228,650	60,570	20,250
1948–49	6,394,720	1,187,100	502,490	646,780	248,360	263,110	64,790	27,790

APPENDIX XLVII—*cont.*

Statement showing the estimated Production of Principal Crops in Madras State—cont.

Year.	Bengalgram. (10) TONS.	Horsegram. (11) TONS.	Greengram. (12) TONS.	Redgram. (13) TONS.	Blackgram. (14) TONS.	Chillies. (15) TONS.	Sugarcane (Jaggery and Gur.) (16) TONS.	Groundnut.* (17) TONS.
1921–22	22,290	128,350	..	..	..	..	314,580	678,260
1922–23	24,820	154,610	..	..	..	..	358,010	822,590
1923–24	24,100	117,090	..	..	..	..	320,400	746,280
1924–25	24,470	148,580	..	..	..	..	313,220	948,110
1925–26	26,120	175,970	..	..	..	..	315,460	1,263,660
1926–27	8,460	121,140	..	..	..	..	304,570	1,207,060
1927–28	15,500	132,010	..	..	..	..	282,520	1,670,550
1928–29	16,430	150,850	..	..	..	..	244,820	1,830,330
1929–30	16,310	180,710	..	..	..	..	275,440	1,521,980
1930–31	16,830	171,590	..	..	..	..	321,285	1,764,940
1931–32	21,680	152,870	..	..	..	..	323,630	1,234,250
1932–33	19,610	163,570	..	..	..	..	339,440	1,728,910
1933–34	22,080	145,390	..	..	..	..	349,000	1,776,700
1934–35	19,530	121,990	..	..	..	..	351,100	920,260
1935–36	15,170	131,610	..	..	..	..	353,680	1,204,020
1936–37	13,970	146,390	..	..	..	..	338,460	1,657,280
1937–38	9,750	120,770	..	..	..	..	278,820	2,059,270
1938–39	10,720	83,590	..	..	..	..	273,860	1,613,000
1939–40	14,810	125,510	..	..	..	..	379,530	1,721,580
1940–41	14,410	144,100	..	..	..	..	484,760	1,924,010
1941–42	11,740	149,930	..	..	..	..	309,280	1,182,810
1942–43	8,410	99,610	..	..	..	..	327,240	1,304,180
1943–44	12,220	125,660	..	..	..	..	435,290	1,603,250
1944–45	15,950	121,000	..	..	..	..	459,910	1,951,040
1945–46	12,330	83,220	38,970	37,610	34,900	128,120	436,670	1,563,880
1946–47	16,890	105,560	40,610	41,610	33,700	147,470	591,910	1,690,440
1947–48	16,480	95,650	40,720	41,450	32,260	148,170	753,500	1,600,960
1948–49	20,600	104,190	39,200	45,080	35,540	143,750	532,530	1,480,100

NOTE.—The figures of yield of pulses relate to unhusked grain. The loss of weight in husking is 20 per cent.

* The yield under Groundnuts is of unshelled nuts. Estimated loss of weight in shelling is 25 per cent.

APPENDIX XLVII—*cont.*

Statement showing the estimated Production of Principal Crops in Madras State—cont.

Year.	Gingelly.	Castor.	Indigo.*	Tobacco.† (Farm cured leaf.)	Cotton† (Irrigated).	Cotton† (Unirrigated).	Total Cotton.†	Barley.
	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
	TONS.	TONS.	CWT.	TONS.	BALES.	BALES.	BALES.	TONS.
1921–22	92,330	36,280	2,430	102,740	78,060	261,410	339,470	..
1922–23	94,930	33,290	1,680	108,130	97,440	330,950	428,390	..
1923–24	86,130	29,580	1,050	113,110	120,050	360,210	480,260	..
1924–25	104,400	37,590	17,120	139,580	142,790	419,920	562,710	..
1925–26	106,460	40,930	19,080	124,980	115,940	448,610	564,550	..
1926–27	84,800	28,890	11,070	112,850	93,970	291,840	385,810	..
1927–28	106,900	33,020	7,400	147,280	111,560	342,460	444,020	..
1928–29	98,710	32,410	10,920	133,750	116,070	407,790	523,860	..
1929–30	100,730	26,030	11,480	136,320	105,810	403,920	509,230	..
1930–31	97,740	28,020	10,240	121,540	68,390	309,240	377,630	..
1931–32	96,510	32,970	7,780	141,980	109,420	311,080	420,500	..
1932–33	112,280	37,510	8,790	137,870	116,860	290,330	407,190	..
1933–34	105,690	31,140	5,100	128,930	129,260	320,280	449,490	..
1934–35	78,640	22,780	9,320	152,990	153,520	321,460	474,980	..
1935–36	85,690	23,210	4,400	132,000	152,070	381,320	533,390	..
1936–37	100,050	24,580	4,680	133,210	148,040	346,220	494,280	..
1937–38	77,000	22,360	3,890	124,840	161,680	340,090	501,770	..
1938–39	93,760	22,410	3,940	119,430	74,640	294,600	369,240	..
1939–40	89,870	25,630	4,070	141,250	111,510	340,590	452,100	..
1940–41	102,540	27,390	9,840	126,810	174,470	355,700	530,170	..
1941–42	84,000	23,400	5,690	129,800	190,720	371,970	562,690	..
1942–43	97,560	22,980	6,560	113,930	186,560	288,360	474,920	..
1943–44	81,270	24,640	7,430	(cwts.) 93,640	168,080	314,400	482,480	..
1944–45	76,180	25,180	10,940	(cwts.) 132,600	109,980	271,880	381,810	..
1945–46	67,200	19,160	7,750	132,920	140,500	220,170	360,670	..
1946–47	78,850	19,350	5,060	108,080	119,450	216,330	335,780	..
1947–48	72,060	20,060	4,430	107,230	77,996	188,187	266,093	410
1948–49	70,600	21,100	2,890	114,480	100,440	241,210	341,650	320

* The figures under Indigo represent the yield if whole crop is manufactured into dye. But there is no information about the quantity actually manufactured into dye or used as green manure on wet lands.

† The figures under Cotton are in bales of 400 lb. lint.

APPENDIX XLVII—*cont.*

Statement showing the estimated Production of principal Crops in Madras State—cont.

Year.	Wheat. (26)	Onions. (27)	Potatoes. (28)	Ginger. (29)	Pepper. (30)
	TONS.	TONS.	TONS.	TONS.	TONS.
1945–46	..	331,670	53,490	..	..
1946–47	..	177,080	52,580	4,180	9,280
1947–48	1,020	210,470	46,580	3,160	8,070
1948–49	2,320	229,150	50,770	3,540	7,610

NOTE.—Figures of production in respect of these crops are furnished only from 1945–46 in the Season and Crop Report published by the Board of Revenue.

APPENDIX XLVIII.

Statement showing yield per acre attained in each of the years from 1921–22 *to* 1947–48.

(The figures denote average for the State.)

Year.	Paddy irrigated.	Paddy unirrigated.	Cholam irrigated.	Cholam unirrigated.	Cumbu irrigated.	Cumbu unirrigated.	Ragi irrigated.	Ragi un-irrigated.	Korra.	Varagu.	Samai.	Maize.	Bengal gram.	Horse gram.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LB.
1921–22	1,730	1,110	1,380	520	1,170	520	1,440	700	400	820	450	1,110	450	180
1922–23	1,700	1,180	1,380	510	1,160	580	1,450	710	360	830	450	1,130	440	190
1923–24	1,608	1,061	1,217	507	1,082	467	1,316	623	353	791	398	1,013	510	161
1924–25	1,693	1,089	1,266	558	1,201	539	1,439	719	483	855	477	1,075	502	202
1925–26	1,747	1,138	1,367	549	1,187	531	1,416	719	504	832	468	1,088	498	215
1926–27	1,556	1,083	1,322	491	1,171	500	1,388	693	358	737	441	781	315	159
1927–28	1,730	1,147	1,323	537	1,094	503	1,353	752	448	798	455	923	471	190
1928–29	1,758	1,148	1,474	566	1,185	530	1,466	742	466	861	455	1,064	497	193
1929–30	1,689	1,141	1,424	571	1,170	513	1,466	698	414	888	456	1,062	486	191
1930–31	1,679	1,170	1,393	528	1,170	524	1,459	729	448	855	462	957	444	200
1931–32	1,722	1,154	1,383	531	1,199	535	1,453	713	400	849	451	1,024	462	190
1932–33	1,737	1,147	1,404	562	1,221	551	1,506	747	480	836	476	1,018	489	208
1933–34	1,666	1,144	1,405	577	1,164	532	1,462	735	369	818	448	976	487	196
1934–35	1,664	1,103	1,242	479	1,065	453	1,337	659	298	764	375	924	379	164
1935–36	1,706	1,113	1,297	530	1,144	515	1,387	652	438	777	419	895	450	179
1936–37	1,738	1,217	1,343	497	1,136	504	1,420	685	370	804	431	947	378	186
1937–38	1,705	1,220	1,011	489	1,133	500	1,425	693	318	740	411	977	418	164
1938–39	1,504	1,035	1,091	516	998	472	1,287	590	421	578	381	946	473	154
1939–40	1,608	1,187	1,297	550	1,060	499	1,332	690	426	710	430	960	488	187
1940–41	1,717	1,181	1,374	565	1,167	541	1,389	720	447	823	470	1,089	486	205
1941–42	1,722	1,266	1,327	487	1,140	498	1,318	662	338	768	482	919	452	197
1942–43	1,573	1,181	1,208	433	1,026	441	1,216	619	273	696	375	949	371	154
1943–44	1,590	1,193	1,160	450	1,048	458	1,312	653	283	727	390	923	418	170
1944–45	1,631	1,158	1,270	506	1,092	476	1,298	644	347	723	394	960	449	175
1945–46	1,441	1,196	1,101	419	891	410	1,088	566	245	627	337	918	414	138
1946–47	1,569	1,204	1,012	369	931	415	1,230	610	285	633	347	890	377	164
1947–48	1,466	1,076	985	444	888	415	1,154	547	332	564	309	958	436	157
1948–49	1,431	1,154	1,060	468	878	319	1,152	560	326	628	329	927	449	160
Normal yield ..	1,794	1,308	1,467	577	1,218	544	1,494	716	394	841	441	1,058	500	200
	$\underbrace{\qquad\qquad}_{1,601}$		$\underbrace{\qquad\qquad}_{661}$		$\underbrace{\qquad\qquad}_{627}$		$\underbrace{\qquad\qquad}_{1,127}$							

APPENDIX XLVIII—*cont.*

Statement showing yield per acre attained in each of the years from 1921–22 *to* 1947–48—cont.

(The figures denote average for the State.)

Year. (1)	Sugarcane. (16)	Groundnut. (17)	Gingelly. (18)	Castor. (19)	Cotton irrigated. (20)	Cotton un-irrigated. (21)	Indigo. (22)	Tobacco. (Farm cured leaf.) (23)	Redgram. (24)	Blackgram. (25)	Green gram. (26)	Chillies. (27)	Onions. (28)
	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LB.	LB.
1921–22	5,910	1,050	270	210	240	63	28	1,130					
1922–23	6,120	1,050	290	230	250	61	26	1,130					
1923–24	5,917	923	277	195	229	59	26	1,152					
1924–25	6,357	1,115	298	235	231	64	27	1,199					
1925–26	6,263	1,089	302	243	222	67	28	1,146					
1926–27	5,959	1,009	279	168	219	57	23	1,089					
1927–28	5,973	1,122	286	205	233	71	21	1,196					
1928–29	6,157	1,114	291	211	223	72	25	1,174					
1929–30	6,289	1,062	292	228	280	70	24	1,190					
1930–31	6,265	1,107	294	222	281	64	24	1,122					
1931–32	6,244	1,049	289	224	252	61	23	1,188					
1932–33	6,288	1,101	301	236	238	66	21	1,206		Information not availabe.			
1933–34	6,426	1,053	283	229	248	66	19	1,165					
1934–35	6,276	877	270	183	281	63	19	1,172					
1935–36	6,422	1,068	256	202	227	64	19	1,056					
1936–37	6,336	1,062	279	209	218	62	17	1,179					
1937–38	6,375	990	217	203	219	61	19	950					
1938–39	6,243	958	240	186	197	66	15	836					
1939–40	6,177	1,066	274	216	226	68	15	1,030					
1940–41	6,715	1,099	292	230	248	67	19	915					
1941–42	6,323	952	271	216	252	66	16	861					
1942–43	6,024	864	260	186	258	60	18	896					
1943–44	6,805	1,012	261	198	258	65	21	881					
1944–45	6,621	1,016	277	198	266	72	25	902					
1945–46	6,087	841	251	182	249	64	20	820	251	254	190	988	9,676
1946–47	6,537	919	262	189	254	63	21	796	257	255	192	905	9,009
1947–48	6,189	882	253	187	247	64	22	818	275	248	198	909	9,176
1948–49	6,790	896	258	206	225	65	19	796	282	239	195	961	9,968
Normal yield ..	6,886	1,120	303	220	286	78	28	992	336	303	238	1,130	11,200
					97								

NOTE.—(1) The normal yield for crops noted in the statement were those fixed in 1919.

(2) The normal yield per acre under *Sugarcane* is based on the results of crop cutting experiments conducted during the years 1935–36, 1937–38 and 1938–39.

(3) The normal yield per acre under *Tobacco* is based on the figures reported by Director of Agriculture based on enquiries made during the marketing survey.

(4) Figures of normal yield per acre for *each variety of cotton*—

(i) Irrigated Cambodia—
300 lb. in Coimbatore and Ramanathapuram.
275 lb in Tiruchirappalli.
250 lb. in other districts.

(ii) Irrigated Karunganni—
150 lb.

(iii) Dry Cambodia—
125 lb. in Coimbatore.
120 lb. in Madurai and Ramanathapuram.
100 lb. in Salem, Tiruchirappalli and Tirunelveli.
50 lb. in other districts.

(iv Uppam—
65 lb.

(v) Dry Karunganni—
85 lb. n Coimbatore.

(vi) Nadam and Bourbon—
20 lb.

(vii) Tinnevellies—
108 lb.

(5) Tobacco—

	Norma yield *per acre.*
	LB.
(i) Virginia type (flue cured)	750
(ii) Country tobacco	1,000 in East Godavari, West Godavari, Krishna and Guntur.
(iii) Do.	1,500 in Nellore.

	Normal yield per acre of country tobacco (sundried.)	
	Irrigated.	Unirrigated.
	LB.	LB.
Bellary	950	650
Anantapur	1,050	700
Cuddapah	2,000	600
Salem	1,000	600
Tiruchirapalli	1,250	650

APPENDIX XLIX.

Statement showing the harvest prices per imperial maund of 82-2/7 lb. of the principal Foodgrain*—Rice *based on the average of the retail prices reported by Collectors as prevailing in two or three of the principal markets in each district.

Year. (1)	Visakhapatnam. (2)	East Godavari. (3)	West Godavari. (4)	Krishna. (5)	Guntur. (6)	Kurnool. (7)	Bellary. (8)	Anantapur. (9)	Cuddapah. (10)	Nellore. (11)	Chingleput. (12)	South Arcot. (13)
	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.
					RICE.							
1921–22	7 9	6 7	..	6 14	7 4	7 2	7 11	8 0	8 5	6 6	7 2	7 2
1922–23	6 4	5 12	..	6 0	6 6	6 11	7 4	7 4	7 11	5 9	6 1	6 3
1923–24	6 11	6 6	..	6 4	6 9	7 13	7 9	7 9	9 12	6 1	7 0	6 1
1924–25	6 11	5 13	7 0	7 6	6 11	7 11	8 0	7 13	10 0	6 11	7 13	7 11
1925–26	6 11	6 5	6 5	6 5	6 11	7 2	7 5	6 11	8 5	6 11	6 3	6 8
1926–27	6 13	7 0	6 14	7 6	7 2	7 6	8 0	7 5	7 13	7 0	7 5	7 11
1927–28	6 11	7 0	6 12	6 13	6 13	7 3	7 13	7 3	8 5	7 4	8 0	8 3
1928–29	6 6	6 5	6 4	6 1	5 14	6 15	7 2	6 15	7 7	7 3	5 15	7 6
1929–30	6 12	6 1	5 14	5 10	5 12	6 9	7 1	6 8	6 15	6 7	5 7	6 6
1930–31	4 13	4 1	3 11	4 3	3 13	5 6	5 5	4 14	5 10	3 3	3 12	4 8
1931–32	4 12	3 11	3 14	4 4	3 8	4 9	5 1	4 5	4 8	3 11	8 9	4 1
1932–33	4 8	2 14	3 2	3 11	3 8	4 6	4 6	3 14	4 11	4 0	3 5	2 14
1933–34	3 3	2 6	2 8	2 10	2 7	3 12	3 15	3 0	3 12	3 4	3 3	3 2
1934–35	3 10	3 9	3 12	3 10	3 6	4 4	4 12	4 4	4 10	4 9	3 10	3 11
1935–36	3 15	3 8	3 6	3 8	3 13	4 5	4 12	3 8	4 8	4 5	3 9	3 15
1936–37	3 15	3 6	3 3	3 10	3 4	4 0	4 10	8 9	4 7	4 3	3 11	3 12
1937–38	4 1	3 11	3 10	3 14	3 13	4 3	4 13	8 14	4 5	5 0	3 4	3 14
1938–39	8 14	3 13	3 9	3 15	3 11	4 7	4 13	3 9	4 2	4 15	4 2	4 2
1939–40	4 6	4 1	4 4	4 15	3 13	4 14	5 12	4 6	4 9	4 12	4 11	3 15
1940–41	5 4	5 4	4 14	5 2	4 13	5 8	6 1	4 12	5 5	4 12	4 7	3 14
1941–42	5 13	5 8	5 0	6 5	5 13	6 12	6 6	5 5	5 5	6 0	5 3	4 13
1942–43	8 4	8 0	7 7	7 12	7 13	8 5	8 11	7 10	0 1	8 10	9 9	7 10
1943–44	9 13	9 1	8 7	9 5	9 4	10 7	10 4	9 12	10 1	9 13	8 10	7 10
1944–45	9 12	8 15	8 8	8 8	9 1	9 4	10 1	10 3	9 15	8 11	10 0	9 11
1945–46	10 10	9 2	8 4	8 12	8 14	9 8	10 8	10 6	9 13	10 3	10 8	9 8
1946–47	11 7	9 2	8 5	9 0	9 3	10 6	10 15	11 8	10 7	10 2	10 13	9 12
1947–48	11 3	11 0	10 4	10 1	10 14	12 12	15 15	14 7	12 5	14 0	13 3	14 11
1948–49	80 7	16 10	12 7	13 13	13 11	15 0	16 15	16 9	24 7	14 5	16 12	16 5

APPENDIX XLIX—*cont.*

Statement showing the harvest prices per imperial maund of 82-2/7 lb. of the principal Foodgrain—**Rice** *based on the average of the retail prices reported by Collectors as prevailing in two or three of the principal markets in each district*—cont.

Year. (1)	Chittoor. (14)	North Arcot. (15)	Salem. (16)	Coimbatore. (17)	Tiruchirapalli. (18)	Tanjore. (19)	Madurai. (20)	Ramanathapuram. (21)	Tirunelveli. (22)	Malabar. (23)	South Kanara. (24)	The Nilgiris. (25)
	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.
					RICE—*cont.*							
1921-22	6 12	7 4	8 8	7 11	7 11	7 13	7 13	6 11	7 2	7 4	6 9	8 8
1922-23	5 13	7 7	7 9	7 8	7 13	7 13	7 11	7 0	7 0	7 0	6 11	8 0
1923-24	6 9	6 14	8 0	7 0	7 9	6 7	6 11	7 2	6 4	7 0	6 11	8 5
1924-25	7 0	8 5	8 5	8 0	9 8	8 14	8 8	9 13	7 8	7 11	7 0	9 2
1925-26	6 8	7 8	8 5	7 11	8 8	7 11	7 8	8 0	7 5	7 2	7 5	8 14
1926-27	7 2	7 6	8 5	8 0	8 3	7 0	7 5	8 0	7 2	7 0	6 11	8 0
1927-28	7 7	7 10	8 8	8 1	8 1	8 3	7 3	7 3	7 5	7 0	6 4	7 14
1928-29	6 14	7 3	8 12	7 9	8 4	7 11	6 11	6 12	6 7	6 12	5 15	7 11
1929-30	6 6	5 11	7 0	7 3	6 15	6 13	5 10	5 2	5 1	6 0	5 8	7 5
1930-31	4 6	3 9	5 4	5 6	5 12	5 14	4 7	4 5	4 15	5 0	5 6	5 9
1931-32	3 12	3 2	4 11	4 5	4 3	4 5	4 4	3 15	3 14	4 0	3 14	4 10
1932-33	3 14	3 6	3 14	4 2	3 13	3 10	3 3	3 3	3 8	3 10	3 10	4 6
1933-34	3 3	3 1	3 4	3 14	3 1	3 1	3 3	2 14	3 4	2 15	3 7	..
1934-35	3 12	3 10	4 5	4 2	4 1	3 10	4 1	3 8	3 15	3 6	3 8	..
1935-36	3 12	3 7	4 9	4 12	4 1	4 0	4 1	3 10	3 13	3 11	3 7	..
1936-37	3 9	3 12	4 2	4 7	3 12	3 11	3 13	3 4	3 2	3 7	3 9	..
1937-38	3 11	3 5	5 0	4 4	4 0	3 14	3 11	3 13	3 13	3 10	3 15	..
1938-39	3 10	4 0	4 15	4 7	3 15	3 15	4 4	3 10	3 11	3 9	3 13	..
1939-40	4 0	4 0	4 6	4 6	4 3	4 1	4 5	4 4	4 6	3 12	4 2	..
1940-41	4 0	4 10	4 10	4 13	4 3	4 7	5 1	4 4	4 8	3 12	4 15	..
1941-42	5 5	4 14	5 3	5 10	5 3	5 4	5 6	5 11	5 7	5 5	6 2	..
1942-43	9 3	8 7	8 6	8 8	8 1	7 11	9 1	9 2	9 7	8 7	10 0	..
1943-44	9 3	7 0	9 0	10 3	9 13	9 0	10 3	11 8	10 5	10 6	10 12	..
1944-45	8 13	8 4	9 3	10 5	10 5	9 5	9 7	8 14	10 13	10 3	10 12	..
1945-46	9 1	10 1	9 11	10 1	10 8	9 5	11 5	11 6	10 13	9 9	10 12	..
1946-47	10 15	10 8	9 11	10 5	9 14	9 5	11 6	10 11	11 0	9 10	10 7	..
1947-48	16 14	14 4	11 0	12 8	10 10	11 1	16 14	19 2	14 8	11 15	13 11	..
1948-49	23 0	15 2	15 8	22 8	16 11	12 0	18 3	15 12	19 15	15 0	15 7	..

NOTE.—Blanks to the statement mean that the crop is not an important foodgrain in the district.

APPENDIX L.

Statement showing the harvest prices per imperial maund of 82-2/7 lb. of the principal Foodgrain—Cholam, *based on the averages of the retail prices reported by Collectors as prevailing in two or three of the principal markets in each district.*

Year. (1)	Visakhapatnam. (2)	East Godavari. (3)	West Godavari. (4)	Kri·hna. (5)	Guntur. (6)	Kurnool. (7)	Bellary. (8)	Anantapur. (9)	Cuddapah. (10)	Nellore. (11)	Chingleput. (12)	South Arcot. (13)
		RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS.A.		
				SORGHAM.								
1921–22	..	4 3	..	5 4	5 2	5 4	5 8	5 10	5 2	4 4	..	..
1922–23	..	3 0	..	4 10	4 7	3 10	4 6	3 5	3 15	4 5	..	..
1923–24	..	3 13	..	3 11	4 7	4 5	5 1	3 15	4 0	4 6	..	..
1924–25	..	4 0	4 13	5 0	4 10	4 5	4 13	5 5	4 14	4 8	..	..
1925–26	..	4 5	4 11	4 8	4 2	3 3	4 2	3 13	3 6	4 5	..	..
1926–27	..	4 3	5 3	5 0	4 6	3 11	4 8	4 0	4 0	4 10	..	..
1927–28	..	3 3	4 13	5 1	4 13	4 3	4 8	4 8	4 13	4 7	..	..
1928–29	..	3 11	4 5	4 7	4 3	3 9	3 12	4 0	4 3	3 6	..	..
1929–30	..	4 1	3 12	3 9	3 15	3 4	3 12	3 10	3 5	3 2	..	..
1930–31	..	2 14	2 4	2 13	3 1	2 2	2 1	2 6	2 0	2 5	..	..
1931–32	..	2 14	2 14	3 6	2 11	2 0	2 2	2 3	2 6	2 6	..	..
1932–33	..	2 6	3 2	2 14	2 11	2 5	2 0	1 14	2 3	2 0	..	..
1933–34	..	1 7	1 12	2 1	1 14	1 15	2 1	2 1	2 0	1 15	..	..
1934–35	..	2 5	2 12	3 2	2 11	2 6	3 3	3 1	2 5	2 6	..	..
1935–36	..	2 3	2 8	3 0	2 14	2 5	2 8	2 6	2 3	2 5	..	..
1936–37	..	2 11	2 12	3 0	3 0	2 0	2 14	2 2	1 15	2 10	..	..
1937–38	..	2 8	3 0	3 0	3 0	2 7	2 6	1 15	2 5	2 4	..	..
1938–39	..	2 10	2 14	3 7	2 12	2 5	2 7	2 1	2 5	2 2	..	..
1939–40	..	2 15	3 4	3 11	3 0	2 4	2 8	2 5	2 10	2 14	..	..
1940–41	..	3 4	3 5	3 0	3 3	2 8	2 8	2 5	2 6	2 14	..	..
1941–42	..	3 7	3 13	3 13	3 7	2 14	3 2	2 11	2 13	3 4	..	..
1942–43	..	5 5	5 13	6 14	5 3	3 7	6 5	4 13	4 13	7 9	..	..
1943–44	..	5 7	6 0	8 6	9 8	8 15	7 2	7 12	8 8	7 13	..	..
1944–45	..	6 6	6 10	7 7	8 13	7 4	5 0	7 7	5 8	8 13	..	..
1945–46	..	6 6	6 10	7 13	9 2	6 7	6 15	7 11	6 0	8 13	..	..
1946–47	..	6 9	6 12	..	8 0	7 6	7 7	7 11	6 15	..	..	..
1947–48	..	9 10	7 12	..	8 8	7 14	12 9	..	8 7	9 13	..	..
1948–49	..	9 0	8 5	7 13	10 7	14 15	..	13 7	14 6	9 2	..	..

APPENDIX L—*cont.*

Statement showing the harvest prices per imperial maund of 22-2/7 lb. of the principal Foodgrain—Cholam, *based on the averages of the retail prices reported by Collectors as prevailing in two or three of the principal markets in each district*—cont.

Year. (1)						Chittoor. (14)	North Arcot. (15)	Salem. (16) RS. A.	Coimbatore. (17) RS. A.	Tiruchirappalli (18) RS. A.	Tanjore. (19)	Madurai. (20) RS. A.	Ramanathapuram. (21) RS. A.	Tirunelveli. (22) RS. A.	Malabar. (23)	South Kanara. (24)	The Nilgiris. (25)
								SORGHAM—*cont.*									
1921-22	..	..	..	..	..	..	..	4 14	5 9	4 8	..	4 14	4 15	4 6	..	..	..
1922-23	..	..	..	..	..	..	..	4 1	4 15	4 3	..	5 8	5 2	4 5	..	..	..
1923-24	..	..	..	..	..	..	..	4 3	5 10	4 14	..	5 2	4 7	4 3	..	..	..
1924-25	..	..	..	..	..	..	..	5 2	6 5	5 5	..	5 13	4 6	4 8	..	..	..
1925-26	..	..	..	..	..	..	..	4 14	5 13	4 14	..	5 2	4 8	4 11	..	..	..
1926-27	..	..	..	..	..	..	..	5 2	5 5	5 2	..	5 2	4 8	4 3	..	..	..
1927-28	..	..	..	..	..	..	..	4 9	5 0	4 11	..	4 9	3 9	4 6	..	..	..
1928-29	..	..	..	..	..	..	..	4 6	5 2	4 6	..	4 12	4 3	3 15	..	..	..
1929-30	..	..	..	..	..	..	..	3 9	5 4	3 14	..	4 1	3 8	2 14	..	..	..
1930-31	..	..	..	..	..	..	..	2 13	3 14	2 7	..	2 15	2 10	2 8	..	..	..
1931-32	..	..	..	..	..	..	..	2 6	2 8	2 7	..	2 9	2 8	2 3	..	..	..
1932-33	..	..	..	..	..	..	..	2 3	2 8	2 2	..	2 5	2 2	2 0	..	..	..
1933-34	..	..	..	..	..	..	..	2 10	2 0	1 10	..	2 0	1 15	1 8	..	..	..
1934-35	..	..	..	..	..	..	..	3 0	2 8	2 12	..	2 7	2 11	2 9	..	..	..
1935-36	..	..	..	..	..	..	..	2 14	2 15	2 15	..	3 3	2 4	2 11	..	..	..
1936-37	..	..	..	..	..	..	..	2 11	2 11	2 11	..	2 8	2 0	2 0	..	..	..
1937-38	..	..	..	..	..	..	..	2 12	2 11	2 6	..	2 8	2 0	2 3	..	..	..
1938-39	..	..	..	..	..	..	..	3 2	2 13	3 1	..	2 14	2 4	2 11	..	..	..
1939-40	..	..	..	..	..	..	..	2 10	3 1	2 13	..	3 1	2 5	2 14	..	..	..
1940-41	..	..	..	..	..	..	..	2 9	2 12	2 13	..	2 13	2 5	2 9	..	..	..
1941-42	..	..	..	..	..	..	..	2 13	3 3	3 3	..	3 5	3 7	3 4	..	..	..
1942-43	..	..	..	..	..	..	..	5 14	5 14	6 5	..	7 1	6 6	6 6	..	..	..
1943-44	..	..	..	..	..	..	..	7 5	10 6	7 13	..	9 13	7 5	6 2	..	..	..
1944-45	..	..	..	..	..	..	..	7 2	10 1	7 4	..	7 10	7 0	6 0	..	..	..
1945-46	..	..	..	..	..	..	..	8 6	7 11	7 5	..	7 4	7 2	7 4	..	..	..
1946-47	..	..	..	..	..	..	..	8 4	..	7 8	..	8 15	7 2	7 4	..	..	..
1947-48	..	..	..	..	..	..	..	8 14	..	9 10	..	..	15 4	10 12	..	..	..
1948-49	..	..	..	..	..	..	..	9 5	..	9 9	..	18 0	11 3	8 7	..	..	..

NOTE.—Blanks in the statement mean that the crop is not an important foodgrain in the district.

APPENDIX LI.

Statement showing the harvest prices per imperial maund of 82⅐ lb. of the principal foodgrain—Cumbu, based on the averages of the retail prices reported by Collectors as prevailing in two or three of the principal markets in each district.

Year. (1)	Visakhapatnam. (2)	East Godavari. (3)	West Godavari. (4)	Krishna. (5)	Guntur. (6)	Kurnool. (7)	Bellary. (8)	Anantapur. (9)	Cuddapah. (10)	Nellore. (11)	Chingleput. (12)	Soth Arcot. (13)
	RS. A..				RS. A.	RS. A.		RS. A.	RS. A.	RS. A.		RS. A.
					BAJRA.							
1921–22	4 7	..	..	..	5 14	5 8	..	4 4	4 13	5 3	..	5 1
1922–23	3 6	..	..	..	4 10	4 14	..	4 13	3 15	4 3	..	5 2
1923–24	4 1	..	..	..	5 1	4 10	..	3 14	3 13	4 5	..	4 11
1924–25	3 14	..	..	..	4 8	4 11	..	4 11	4 2	4 5	..	5 10
1925–26	3 11	..	..	..	4 8	4 8	..	3 11	4 0	4 3	..	5 2
1926–27	4 5	..	..	..	4 11	4 13	..	3 13	3 5	5 0	..	5 2
1927–28	3 13	..	..	..	5 0	5 0	..	4 3	4 4	5 5	..	4 15
1928–29	3 7	..	..	..	4 12	4 13	..	3 11	4 2	4 5	..	4 12
1929–30	3 3	..	..	..	4 5	4 10	..	3 15	4 8	3 13	..	4 4
1930–31	3 0	..	..	..	3 7	3 8	..	2 5	2 4	2 13	..	3 7
1931–32	2 5	..	..	..	2 13	2 13	..	1 14	1 12	2 11	..	2 12
1932–33	1 13	..	..	..	3 3	2 14	..	2 5	2 8	2 10	..	2 8
1933–34	1 10	..	..	..	2 13	2 11	..	1 14	2 2	2 5	..	2 7
1934–35	2 5	..	..	..	2 13	2 14	..	2 10	2 6	2 10	..	2 9
1935–36	2 7	..	..	..	3 5	2 12	..	2 12	2 3	2 9	..	3 6
1936–37	2 3	..	..	..	3 2	2 11	..	2 2	..	2 11	..	2 13
1937–38	2 7	..	..	..	3 2	3 1	..	2 8	..	2 11	..	3 1
1938–39	2 5	..	..	..	2 15	2 10	..	2 5	..	2 10	..	2 7
1939–40	2 9	..	..	..	3 6	2 15	..	2 3	..	3 2	..	3 3
1940–41	3 0	..	..	..	3 10	3 5	..	2 3	2 5	3 2	..	2 13
1941–42	3 4	..	..	..	3 8	3 10	..	2 5	2 11	3 6	..	3 3
1942–43	5 1	..	..	..	5 11	4 4	..	4 14	4 13	4 2	..	4 5
1943–44	6 2	..	..	..	10 0	8 15	..	5 10	5 14	6 14	..	5 9
1944–45	7 7	..	..	..	..	8 15	..	7 5	..	6 15	..	..
1945–46	7 7	..	..	..	..	7 13	..	6 12	..	7 11	..	..
1946–47	6 8	..	..	..	..	8 14	..	7 6	..	7 0	..	6 0
1947–48	8 10	..	..	..	10 4	..	..	8 15	..	12 13	..	..
1948–49	..	..	..	..	12 8	17 2	..	17 30	..	13 5	..	..

APPENDIX LI—*cont.*

***Statement, showing the harvest prices per imperial maund of 82⅐ lb. of the principal foodgrain—Cumbu based on the average of the retail prices reported by Collectors as prevailing in two or three of the principal markets in each district*—cont.**

Year.	Chittoor. (14)	North Arcot. (15)	Salem. (16)	Coimbatore. (17)	Iruchirappalli. (18)	Tanjore. (19)	Madurai. (20)	Ramanadhapuram. (21)	Tirunelveli. (22)	Malabar. (23)	South Kanara. (24)	The Nilgiris. (25)
	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.			
					BAJRA—*cont.*							
1921-22	3 12	4 5	4 3	5 5	5 2	..	5 9	6 1	5 5	..	..	..
1922-23	4 2	4 13	5 3	5 13	4 12	..	5 8	5 14	5 1	..	..	..
1923-24	4 0	5 2	4 10	7 4	4 13	..	5 4	4 14	4 14	..	..	..
1924-25	4 2	5 2	6 5	5 5	6 5	..	6 10	5 10	6 2	..	..	..
1925-26	3 11	4 11	4 13	4 14	6 0	..	6 2	6 3	5 2	..	..	..
1926-27	3 11	4 11	4 8	5 0	5 5	..	5 11	5 10	5 13	..	..	..
1927-28	4 7	4 3	4 4	4 14	5 5	..	5 15	6 2	5 8	..	..	..
1928-29	4 12	4 4	4 12	5 5	5 9	..	5 8	4 14	5 2	..	..	..
1929-30	3 8	4 2	5 2	4 12	4 14	..	5 0	3 4	3 13	..	..	..
1930-31	2 4	2 14	3 4	3 13	3 9	..	3 14	2 0	2 10	..	..	..
1931-32	1 14	2 3	2 0	2 9	2 1	..	3 0	3 0	3 3	..	..	..
1932-33	2 10	2 3	2 2	2 14	2 8	..	2 14	2 11	2 11	..	..	..
1933-34	2 1	2 4	2 4	2 10	2 9	..	2 3	2 9	2 8	..	..	..
1934-35	2 4	2 4	2 7	3 0	2 15	..	2 10	3 5	3 9	..	..	..
1935-36	2 8	2 12	2 12	3 6	3 3	..	2 13	3 3	3 0	..	..	..
1936-37	2 6	2 2	2 11	3 5	2 11	..	2 10	2 1	2 9	..	..	..
1937-38	2 5	2 8	2 9	3 4	2 11	..	2 7	2 3	2 5	..	..	..
1938-39	2 0	2 0	2 10	3 4	3 0	..	2 12	3 1	3 10	..	..	..
1939-40	2 4	2 8	4 5	3 6	3 3	..	3 3	2 12	3 2	..	..	..
1940-41	2 14	2 8	2 13	3 0	2 13	..	3 0	2 12	3 4	..	..	..
1941-42	2 15	2 15	3 1	3 4	3 3	..	3 5	3 10	3 13	..	..	..
1942-43	5 15	4 1	6 9	5 15	6 2	..	6 12	6 7	6 10	..	..	..
1943-44	7 6	7 1	10 5	11 4	9 6	..	8 10	8 8	9 11	..	..	..
1944-45	6 11	6 10	7 6	10 14	9 14	..	8 14	9 6	8 1	..	..	..
1945-46	6 13	7 8	8 0	7 11	8 1	..	7 5	7 4	7 14	..	..	..
1946-47	6 15	7 8	..	7 11	8 15	..	10 15	..	..	..	..	..
1947-48	8 12	..	8 3	8 5	8 4	..	..	..		..	..	..
1948-49	15 10	15 15	13 7	17 4	..	..	21 10	17 3	..	..	..	..

NOTE.—Blanks in the statement mean that the crop is not an important foodgrain in the district.

APPENDIX LII.

Statement showing the harvest prices per imperial maund of 82⁶⁄₇ lb. of the principal foodgrain, Ragi, based on the averages of the retail prices reported by Collectors as prevailing in two or three of the principal markets in each district.

RAGI.

Year. (1)	Visakhapatnam. (2)	East Godavari. (3)	West Godavari. (4)	Krishna. (5)	Guntur. (6)	Kurnool. (7)	Bellary. (8)	Anantapur. (9)	Cuddapah. (10)	Nellore. (11)	Chingleput. (12)	South Arcot (13)
	RS. A.	RS. A.	RS. A.	RS. A.				RS. A.	RS. A.	RS. A.	RS. A.	RS. A.
1921–22	3 15	3 15	..	4 3	..	..	..	4 3	4 5	4 6	5 5	4 14
1922–23	3 1	3 5	..	3 11	..	..	..	3 9	4 1	4 0	5 0	5 1
1923–24	3 10	3 4	..	3 10	..	..	..	4 1	4 3	3 11	4 6	4 9
1924–25	3 5	3 14	4 0	4 0	..	..	..	4 6	4 6	4 5	4 14	5 5
1925–26	3 3	3 6	3 8	3 10	..	..	..	3 11	3 10	3 11	4 6	4 11
1926–27	4 0	3 11	4 0	4 0	..	..	..	3 5	4 11	4 3	5 0	4 14
1927–28	3 13	4 1	4 0	3 13	..	..	..	3 14	4 5	4 0	4 10	4 11
1928–29	3 5	3 5	3 12	3 5	..	..	..	3 11	3 11	3 4	4 11	4 8
1929–30	2 15	3 6	3 5	3 4	..	..	..	3 10	3 1	2 12	4 5	4 0
1930–31	2 10	2 7	2 9	2 8	..	..	..	2 1	1 14	2 3	3 3	2 15
1931–32	2 3	2 2	2 7	2 2	..	..	..	2 1	2 1	2 3	2 8	2 8
1932–33	1 14	2 2	2 2	2 2	..	..	..	2 2	2 3	2 2	2 13	2 0
1933–34	1 8	1 8	1 12	1 5	..	..	..	1 9	1 13	1 11	2 10	2 4
1934–35	2 3	2 0	2 3	2 8	..	..	..	2 8	2 6	2 4	2 9	2 4
1935–36	2 6	2 0	2 3	2 7	..	..	..	2 8	2 0	2 3	3 0	2 12
1936–37	2 3	2 2	1 14	2 6	..	..	..	2 1	2 1	2 0	2 7	2 5
1937–38	2 3	2 1	2 3	2 5	..	..	..	2 2	1 14	2 2	2 7	2 4
1938–39	2 0	2 8	2 3	2 8	..	..	..	2 0	2 0	2 2	2 3	2 4
1939–40	2 4	2 11	2 13	3 2	..	..	..	2 2	3 5	2 13	3 1	3 2
1940–41	2 11	3 5	2 15	3 1	..	..	..	2 4	3 0	2 13	3 2	2 9
1941–42	2 13	3 2	3 8	3 4	..	..	..	2 4	2 11	3 1	3 2	2 15
1942–43	4 4	4 6	4 9	4 15	..	..	..	4 1	4 8	6 5	5 0	4 14
1943–44	5 7	5 7	5 2	5 11	..	..	..	7 4	8 4	6 15	8 6	5 13
1944–45	6 7	4 7	5 1	5 12	..	..	..	6 15	6 8	7 1	8 3	6 8
1945–46	7 8	4 11	5 5	5 11	..	..	..	6 12	6 5	7 7	7 12	6 15
1946–47	6 9	5 0	5 5	..	..	..	..	9 4	5 10	..	..	6 7
1947–48	7 8	7 13	6 4	..	..	..	..	7 2	11 8	10 2	..	9 10
1948–49	11 4	9 4	6 14	..	..	..	..	12 5	12 2	..	11 3	13 15

APPENDIX LII—*cont.*

***Statement showing the harvest prices per imperial maund of 82$\frac{2}{7}$ lb. of the principal foodgrain, Ragi, based on the averages of the retail prices reported by Collectors as prevailing in two or three of the principal markets in each district*—cont.**

RAGI—*cont.*

Year	Chittoor. (14)	North Arcot. (15)	Salem. (16)	Coimbatore. (17)	Tiruchirappalli. (18)	Tanjore. (19)	Madurai. (20)	Ramanathapuram. (21)	Tirunelveli. (22)	Malabar. (23)	South Kanara. (24)	The Nilgiris. (25)
	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.
1921–22	4 0	4 13	4 11	4 15	3 12	5 1	4 6	4 1	4 8	..	..	5 1
1922–23	4 2	4 13	4 9	5 6	4 10	5 5	4 12	4 8	4 1	..	..	5 5
1923–24	4 0	4 9	5 3	4 11	4 2	4 9	4 6	4 12	4 1	..	..	5 11
1924–25	4 5	5 6	4 14	5 10	5 6	6 5	5 3	4 14	4 5	..	..	6 5
1925–26	3 11	4 11	4 6	5 6	5 2	5 3	4 11	4 11	4 0	..	..	6 0
1926–27	3 8	4 13	4 6	5 5	5 0	4 14	4 13	4 2	4 6	..	..	5 0
1927–28	3 15	4 12	4 6	4 13	5 2	4 2	4 12	4 13	4 0	..	..	5 11
1928–29	4 5	4 11	4 5	4 13	5 0	5 4	4 15	3 11	3 13	..	..	5 13
1929–30	4 1	3 10	3 13	4 8	4 15	4 0	3 15	3 10	3 2	..	..	5 2
1930–31	2 2	2 11	2 4	3 11	2 13	2 9	3 0	2 5	2 8	..	..	3 12
1931–32	1 15	2 4	2 7	2 9	2 3	2 8	2 6	2 5	2 4	..	..	2 14
1932–33	2 3	2 6	2 3	2 10	2 3	2 2	2 0	2 8	2 2	..	..	3 14
1933–34	1 8	2 6	1 14	2 5	1 12	1 13	1 12	1 14	1 10	..	..	..
1934–35	2 6	2 5	2 8	3 0	2 13	2 10	2 12	2 8	2 4	..	..	..
1935–36	2 8	2 14	2 10	3 3	2 12	2 12	2 6	2 12	2 10	..	..	..
1936–37	2 2	2 6	2 8	3 1	2 5	2 5	2 1	1 15	2 10	..	..	..
1937–38	1 15	2 6	2 9	2 13	2 4	2 5	2 3	2 2	2 2	..	..	..
1938–39	2 2	2 2	2 9	3 0	2 4	2 7	2 11	2 2	2 5	..	..	..
1939–40	2 6	2 14	2 12	2 12	2 9	2 7	2 11	2 13	2 12	..	..	..
1940–41	2 3	2 10	2 10	2 8	2 9	2 13	2 6	2 8	2 8	..	3 0	..
1941–42	2 15	2 13	2 10	2 14	2 11	2 15	2 14	3 3	3 3	..	3 5	..
1942–43	5 2	5 4	5 1	5 8	4 10	5 10	6 4	5 1	6 0	..	7 11	..
1943–44	7 13	8 6	6 7	10 7	7 14	6 5	8 12	8 8	8 3	..	..	..
1944–45	5 14	7 1	7 0	10 12	8 6	..	7 8	8 3	6 6	..	11 8	..
1945–46	8 3	9 0	7 4	7 5	7 0	..	7 1	7 1	6 10	..	10 7	..
1946–47	8 8	8 5	8 2	7 2	8 8	..	6 14	6 1	5 15	..	10 11	..
1947–48	9 14	8 9	9 2	8 8	8 8	..	..	15 6	7 5	..	12 5	..
1948–49	14 6	22 10	12 15	17 4	..	..	18 10	15 0	7 8	..	..	..

NOTE.—A blank in the statement means that the crop is not an important foodgrain in the district.

APPENDIX LIII.

Wholesale prices of forecast crops reported by Deputy Directors of Agriculture as prevailing during the harvest months.
(*Figures taken from Season and Crop Reports*), 1929–30 *to* 1948–49.

JAGGERY.

(Price per Imperial Maund of 82–2/7 lb)

Year. (1)	Visakhapatnam. (2) RS. A.	East Godavari. (3) RS. A.	Bellary. (4) RS. A.	South Arcot. (5) RS. A.	Chittoor. (6) RS. A.	North Arcot. (7) RS. A.	Salem. (8) RS. A.	Coimbatore. (9) RS. A.	Tiruchirappalli. (10) RS. A.	South Kanara. (11) RS. A.
1929–30	5 6	6 10	6 10	7 1	7 1	7 9	7 8	6 4	7 15	10 0
1930–31	3 5	3 12	5 0	4 1	4 10	4 10	5 6	4 7	5 14	5 13
1931–32	3 5	5 9	5 6	5 5	4 5	4 5	5 2	4 9	5 9	5 0
1932–33	2 14	3 12	4 9	4 2	..	..	4 6	4 6	5 2	4 9
1933–34	2 10	3 6	5 0	4 0	2 12	2 12	4 9	4 9	5 2	5 0
1934–35	5 13	5 6	6 4	4 5	5 6	5 6	4 9	4 9	6 3	5 6
1935–36	3 5	4 0	4 2	3 6	3 5	3 5	4 1	3 14	3 12	5 2
1936–37	2 1	3 3	3 8	3 5	2 14	2 14	3 10	3 14	4 8	4 6
1937–38	3 8	4 2	3 8	3 15	3 0	3 5	5 9	5 9	6 1	6 10
1938–39	6 11	7 4	5 13	6 10	7 1	6 8	6 9	6 9	5 12	6 6
1939–40	6 11	5 15	9 6	5 10	7 1	4 6	6 9	5 12	6 5	6 4
1940–41	3 11	3 7	4 2	3 10	3 5	3 0	2 14	5 10	2 14	4 2
1941–42	5 8	5 7	4 15	5 6	4 2	5 7	3 7	5 13	5 6	5 1
1942–43	9 5	10 6	13 14	12 7	12 1	11 6	11 8	13 13	11 3	13 3
1943–44	9 8	11 1	13 4	12 14	10 4	8 13	11 15	15 13	10 12	12 4
1944–45	7 15	10 0	12 0	9 9	9 12	7 14	10 0	12 4	8 15	11 4
1945–46	11 15	15 3	14 8	13 1	12 0	12 5	12 5	13 10	13 5	12 0
1946–47	16 0	14 2	18 1	13 10	14 9	14 8	15 6	17 0	14 1	15 8
1947–48	11 15	10 12	13 1	12 4	7 4	9 0	13 12	13 8	11 6	12 14
1948–49	12 0	11 4	12 12	19 9	14 8	16 1	14 0	18 0	17 1	12 8

APPENDIX LIV.

Wholesale prices of forecast crops reported by Deputy Directors of Agriculture as prevailing during the harvest months.
(*Figures taken from Season and Crop Reports*), 1929–30 *to* 1948–49.

GROUNDNUT.

(Price per Imperial Maund of 82–2/7 lb.)

Year. (1)	Visakhapatnam. (2) RS. A.	Guntur. (3) RS. A.	Kurnool. (4) RS. A.	Bellary. (5) RS. A.	Anantapur. (6) RS. A.	Cuddapah. (7) RS. A.	South Arcot. (8) RS. A.	North Arcot. (9) RS. A.	Salem. (10) RS. A.	Coimbatore. (11) RS. A.
1929–30	2 13	4 4	4 2	4 0	4 2	5 0	3 8	3 12	4 9	5 0
1930–31	2 12	2 9	2 5	3 5	2 8	2 13	3 1	3 12	1 13	2 8
1931–32	3 1	3 7	3 0	3 2	3 2	3 8	3 4	2 1	3 15	3 4
1932–33	2 13	3 1	3 12	3 4	2 15	4 0	2 8	..	3 4	3 4
1933–34	2 4	1 13	1 6	1 9	1 9	2 4	2 8	2 3	2 1	2 1
1934–35	2 10	3 10	3 15	3 8	3 6	4 2	5 7	4 11	3 12	3 8
1935–36	3 0	3 14	3 0	3 13	3 14	3 1	..	..	3 2	3 4
1936–37	3 7	4 1	3 10	4 8	4 2	3 12	6 4	4 12	2 14	3 13
1937–38	2 14	3 0	2 8	3 8	3 6	3 0	4 10	3 11	3 7	2 12
1938–39	2 9	2 9	2 6	2 6	2 6	2 6	..	2 11	..	2 9
1939–40	3 5	3 2	3 8	3 1	3 0	3 5	..	3 2	..	2 13
1940–41	3 12	3 8	3 0	3 8	3 11	..	3 5	3 7	3 14	3 0
1941–42	4 15	4 13	..	4 1	4 2	4 1	4 7	4 4	4 10	4 4
1942–43	7 5	7 12	..	8 4	8 12	7 10	8 8	7 12	7 5	9 0
1943–44	12 8	10 13	..	12 7	11 8	11 10	10 15	10 14	11 7	12 7
1944–45	9 11	9 13	..	9 8	9 15	9 13	10 0	9 12	9 4	10 14
1945–46	11 14	12 1	11 1	11 6	11 10	11 2	13 1	10 14	13 8	12 5
1946–47	15 9	15 1	15 7	15 0	14 12	14 14	14 3	14 4	14 14	14 12
1947–48	22 11	21 8	21 5	19 4	19 14	17 11	21 8	20 12	20 9	21 5
1948–49	22 5	22 8	21 15	20 8	22 1	20 0	22 5	22 8	23 6	22 6

APPENDIX LV.

Wholesale prices of Forecast Crops reported by Deputy Directors of Agriculture as prevailing during the harvest months.
(*Figures taken from Season and Crop Reports*) 1929–30 *to* 1948–49.

GINGELLY.

(Price per Imperial Maund of 82–2/7 lb.)

Year. (1)	Visakhapatnam. (2)	East Godavari. (3)	West Godavari. (4)	South Arcot. (5)	Salem. (6)	Tiruchirappalli. (7)	Tirunelveli (8)
	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.
1929–30	7 0	..	8 4	10 4	8 0	10 0	8 4
1930–31	4 12	7 6	7 6	6 2	6 4	8 0	8 0
1931–32	4 12	8 0	8 0	6 14	6 14	7 4	8 6
1932–33	6 2	6 14	6 14	6 4	5 2	6 0	5 0
1933–34	3 0	6 4	6 4	5 0	5 2	5 2	5 0
1934–35	5 6	8 0	8 0	8 14	5 0	8 4	8 6
1935–36	6 8	6 14	6 14	5 4	6 14	6 6	6 4
1936–37	4 6	6 14	6 14	6 4	6 4	6 0	6 4
1937–38	6 2	7 0	7 0	5 2	5 6	6 4	5 2
1938–39	5 4	5 15	5 4	5 13	..	6 8	6 10
1939–40	6 8	6 8	5 2	5 9	..	6 8	5 6
1940–41	6 6	6 12	6 12	6 0	6 1	6 8	..
1941–42	5 15	7 3	6 4	6 5	6 7	6 10	7 6
1942–43	11 5	13 2	8 11	11 2	13 0	14 2	14 9
1943–44	15 4	17 5	19 15	17 2	18 11	20 2	18 4
1944–45	18 8	18 12	20 3	20 13	20 11	20 10	22 4
1945–46	22 4	19 14	22 2	22 7	24 0	25 3	25 10
1946–47	27 1	27 5	27 12	26 13	28 13	27 11	29 13
1947–48	28 2	30 3	28 8	27 10	30 2	32 7	26 14
1948–49	27 5	[28 3	30 6	31 1	31 12	34 13	32 0

APPENDIX LVI.

Wholesale prices of Forecast crops reported by Deputy Directors of Agriculture as prevailing during the harvest months. (Figures taken from Season and Crop Reports), 1929–30 to 1948–49.

CASTOR.

(Price per Imperial Maund of 82–2/7 lb.)

Year. (1)	Visakhapatnam. (2)	Guntur. (3)	Kurnool. (4)	Bellary. (5)	Anantapur. (6)	Cuddapah. (7)
	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.
1929–30	7 0	4 4	6 4	4 12	6 4	5 6
1930–31	5 0	..	3 6	2 14	5 0	4 4
1931–32	4 0	5 2	4 0	5 0	4 6	4 14
1932–33	5 6	3 0	2 14	5 6	4 12	4 0
1933–34	..	3 4	2 8	2 14	2 6	2 14
1934–35	..	4 8	4 0	3 2	3 2	3 4
1935–36	..	4 8	4 0	3 2	3 6	4 4
1936–37	5 0	4 6	3 6	4 0	4 4	4 6
1937–38	..	4 10	3 0	3 4	3 4	4 2
1938–39	4 8	4 2	5 4	4 1	3 15	..
1939–40	6 1	5 6	6 14	5 12	5 3	..
1940–41	5 0	4 5	..	4 9	4 15	4 12
1941–42	5 8	5 5	..	4 7	4 8	4 8
1942–43	13 7	13 7	..	8 10	10 4	9 15
1943–44	15 2	12 15	..	12 10	12 14	14 7
1944–45	12 5	12 1	..	10 14	12 2	14 7
1945–46	14 10	15 6	..	7 2	12 3	14 7
1946–47	18 9	22 6	..	12 5	13 6	..
1947–48	22 13	20 9	..	13 10	22 11	..
1948–49	20 7	20 12	..	14 12	..	..

APPENDIX LVII.

Wholesale price of principal crops during the harvest months (figures taken from Season and Crop Reports), 1932–33 to 1948–49.

COTTON.

(Price per imperial maund of 82-2/7 lb.)

Year.	Guntur.	Kurnool district. White Northerns.	Kurnool district. Red Northerns.	Bellary. Adoni. Mungari.	Bellary. Adoni. Hingari.	Bellary. Bellary. Mungari.	Bellary. Bellary. Hingari.	Salem.	Coimbatore. Erode. Cambodia.	Coimbatore. Coimbatore. Cambodia.	Coimbatore. Coimbatore. Karunganni.	Coimbatore. Tiruppur. Cambodia.	Coimbatore. Tiruppur. Karunganni.	Madurai. Cambodia.	Madurai. Karunganni.	Tirunelvelli. Karunganni.	Tirunelvelli. Tinnevellies.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
	RS. A.	RS. A.		RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.	RS. A.
1932–33	16 0	18 12		..	..	15 0	18 4	..	..	23 0	21 0	..	..	21 0	..	..	23 0
1933–34	19 0	20 0		..	..	14 0	21 0	..	..	25 0	21 0	..	..	21 0	..	..	23 0
1934–35	..	27 0		..	..	16 8	23 0	..	..	26 0	25 0	..	..	29 0	..	27 0	25 0
1935–36	..	21 8		..	..	16 8	19 12	..	..	31 0	30 0	..	..	28 0	..	30 0	28 0
1936–37	20 0	20 0		..	..	16 8	18 8	..	..	27 0	26 0	..	..	29 0	..	25 0	24 0
1937–38	20 0	16 0		..	..	13 0	16 0	..	..	25 0	24 0	..	..	18 0	..	17 0	16 0
			RS. A.														
1938–39	14 8	18 12	14 8	12 1	14 2	11 13	14 1	..	..	24 10	21 9	25 5	20 14	17 2	17 1	18 15	17 8
1939–40	22 1	19 12	21 2	20 12	23 12	20 6	21 13	..	..	33 0	27 3	34 2	29 6	29 1	27 13	29 0	28 3
1940–41	18 10	17 1	17 3	18 6	16 12	14 5	21 10	..	29 0	33 3	30 4	32 12	31 14	29 7	26 5	28 2	25 13
1941–42	15 12	19 11	17 13	14 5	18 12	18 4	27 8	..	26 12	31 5	27 13	31 3	28 3	25 15	24 2	..	20 3
1942–43	36 11	31 1	23 1	25 2	21 1	24 12	34 15	74 13	32 12	30 14	75 4	32 5	30 10	69 8	62 7	22 8	60 12
1943–44	37 8	32 1	32 8	24 8	21 1	28 13	28 10	..	..	71 1	55 5	72 0	56 4	46 11	42 9	..	42 2
1944–45	25 13	26 9	27 10	16 12	19 15	18 1	22 14	..	..	59 8	49 3	60 11	52 8	44 13	38 7	..	37 1
1945–46	32 13	34 14	35 8	18 0	21 1	20 9	25 14	59 3	..	65 10	57 5	65 4	66 11	51 5	45 9	..	44 6
1946–47	34 9	41 12	40 15	59 14	21 0	33 12	33 3	58 11	..	61 11	54 10	61 3	54 15	..	44 2	..	43 14
1947–48	38 11	45 13	47 3	31 8	21 1	32 7	33 15	76 11	..	89 1	72 14	87 4	75 1	..	79 8	..	..
1948–49	44 1	64 4	65 14	44 4	56 8	43 10	50 14	78 11	..	81 13	73 5	83 15	74 14	..	..	..	..

APPENDIX LVIII.

Standard Weights and Measures fixed under the Madras Weights and Measures Act of 1948.

In addition to the All-India standards of weight, namely, the maund, seer, tola series and the ten hundred-weight, quarter, pound series, the following are the standards for Madras prescribed under the Act of 1948 :—

PART I.

Standard weights.

I. For general use—

(1) The palam being a weight of three standard tolas.
(2) The Madras seer of eight palams or 24 tolas.
(3) The viss being five Madras seers or 120 tolas.
(4) The Madras Maund being a weight of eight visses or 960 standard tolas.
(5) The kandy being a weight of 20 Madras maunds or 19,200 tolas.

II. For use in the trade in gold and silver—

(a) The following multiples of the standard tolas, viz., 2, 3, 4, 5, 10, 20, 50, 100, 200, 300, 500, 1,000 and 2,000.
(b) The following sub-multiples of the standard tolas, namely, 1/2, 1/4, 1/8, 1/16 and 1/32.

III. For use in the trade in precious stones—

(a) The carat being a weight equivalent to 1/120 of a tola.
(b) The following multiples of the carat, namely, 2, 3, 4, 5, 6, 8, 10, 12, 15, 20, 30, 40 and 60.
(c) The following sub-multiples of the carat, namely, 1/2, 1/4, 1/5, 1/8, 1/10, 1/16, 1/20, 1/50 and 1/100.

IV. For use in the Apothecaries' trade—

(a) The drachm, being a weight equivalent to 60 standard grains.
(b) The ounce being a weight equivalent to eight drachm or 480 standard grains.
(c) The following multiples of the ounce ,namely, 2, 4, 6, 8 and 10.
(d) The following sub-multiples of the ounce, namely, 1/2, 1/4, 1/8 and 1/16.
(e) The scruple, being a weight equivalent to 20 standard grains.
(f) Two scruples, being a weight equivalent to 40 standard grains.
(g) One-half of a scruple, being a weight equivalent to ten standard grains.

PART II.

Measures of length and area.

(a) The standard inch, the standard foot and the standard yard as defined in the Measures of Length Act, 1889.
(b) The link, being a length of 7.92 standard inches.
(c) The chain, being a length of 100 links or 22 standard yards.
(d) The furlong, being a length of 220 standard yards.
(e) The mile, being a length of eight furlongs.
(f) The square inch, being the square of one standard inch.
(g) The square foot, being the square of one standard foot.
(h) The square yard, being the square of one standard yard.
(i) The acre, being an area of 4,840 square yards.

PART III.

Measures of capacity.

I. For general use—

(a) The cubic inch, being the cube of one standard inch.
(b) The cubic foot, being the cube of one standard foot.
(c) The cubic yard, being the cube of one standard yard.
(d) The Madras measure, being equivalent to 108 cubic inches (62½ fluid ounces).
(e) The type seer, being equivalent to 72 cubic inches (41-2/3 fluid ounces).

NOTE.—Three type seers are equivalent to two Madras

(f) The fluid ounce, being equivalent to 1/1,000th of a cubic foot.

NOTE.—One fluid ounce of air-free distilled water at 62°F weights 437.5 standard grains approximately.

(g) The pint, being equivalent to 20 fluid ounces.
(h) The quart, being equivalent to two pints.
(i) The gallon, being equivalent to four quarts.
(j) The bushel, being equivalent to eight gallons.

II. For use in the Apothecaries' trade—

(a) The fluid ounce as defined above.
(b) The following multiples of the fluid ounce, namely, 2, 4, 6, 8, 10, 12, 16, 24 and 32.
(c) The fluid drachm, being equivalent to 1/8th of a fluid ounce.
(d) The following multiples of the fluid drachm, namely, 2, 3, and 4.
(e) The minim, being equivalent to 1/60th of a fluid drachm.
(f) The following multiples of the minim, namely, 2, 3, 4, 5, 10, 20 and 30.

APPENDIX LIX.

Area under improved strains and their characteristics.

RICE.

Strain number.	Name.	Duration (seed to seed). Season.	Days.	Average acre yield in lb.	Area to which strain useful (in lakhs of acres).	Size of grain.	Colour of rice.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Paddy Breeding Station, Coimbatore.					
GEB. 24 ..	.. Kichili samba	June-December .. July-January .. September-February ..	149	3,500	5	Finer than medium ..	Pearl white.
Co. 1 ..	.. Poria Kichili	June-December ..	155	3,600	1	Medium	White.
Co. 2 ..	.. Poombalai	July-January .. September-February ..	152	3,800	5	Do.	Do.
Co. 3 ..	.. Vellai samba	July-January .. September-February ..	161	3,600	1	Do.	Do.
Co. 5 ..	.. Chinna samba	July-January .. September-February ..	164	3,500	½	Do.	Do.
Co. 6 ..	.. Sadai samba	....	176	3,700	..	Do.	Do.
Co. 10 ..	.. Gobi Kar	June-September .. January-April ..	120	3,000	1	Coarse	Do.
Co. 13 ..	.. Arupatham Kodai	January-April .. June-September ..	110	3,000	2	Medium to coarse ..	Do.
Co. 14 ..	.. Perunthandu vellai samba	September-February ..	171	3,000	..	Do. ..	Do.
Co. 15 ..	.. Jada Melagolukulu	July-January ..	190	3,500	½	Medium	Do.
Co. 16 ..	.. Vellai Kar	January-April ..	125	2,700	2	Do.	Do.
Co. 19 ..	.. Chingleput Sirumani	July-January .. September-February ..	190	3,500	4	Do.	Do.
Co. 20 ..	.. Tellahamsa Vadlu	June-December .. January-April .. July January ..	130	3,000	½	Medium fine	Do.
c. [illegible] ..	.. Hybrid sirumani	Do. ..	195	3,000	5	Medium round ..	Do.
c. [illegible] ..	.. Hybrid Nellore samba	Do. ..	200	3,000	½	Medium.	

Agricultural Research Station, Maruteru.

MTU. 1	Bontha Akkulu	June-December	160	2,500	3	Medium	White.
MTU. 3	Potti Basangi	June-September	160	4,000	1	Do.	Do.
MTU. 4	Pedha Basangi	Do.	167	3,500	[illegible]	Do.	Do.
MTU. 5	Bontha Krishnakatukulu	June-December	195	2,800	2	Do.	Do.
MTU. 7	Gutti Kusuma	Do.	205	3,500	..	Do.	Do.
MTU. 8	Vankisannam	Do.	205	2,800	[illegible]	Long fine	Do.
MTU. 9	Garikasannavari	January-April	120	2,500	[illegible]	Coarse	Do.
MTU. 10	Sannakrishnakatukulu	January-December	216	3,000	1	Medium fine	Do.
MTU. 12	Peddha Atragada	Do.	210	3,000	[illegible]	Medium	Do.
MTU. 15	Dalwa Sannam	January-April	125	2,600	[illegible]	Do.	Do.
MTU. 16	Badawa Kusuma	....	200	3,000	1/10	Coarse	Do.
MTU. 19	Sanna Kusuma	June-December	200	3,500	3	Medium fine	Do.

Agricultural Research Station, Aduthurai.

ADT. 1	Red Sirumani	July-January	175	3,000	[illegible]	Short round	White.
ADT. 2	White Sirumani	Do.	165	2,800	1	Do.	Do.
ADT. 3	Kuruvai	January-April June-September	95	3,600	2	Coarse	Dull white.
ADT. 7	White Ottadan	July-January	220	2,000	1/10	Do.	White.
ADT. 8	White Sirumani, (early)	July-January September-February	150	2,800	[illegible]	Short round	Do.
ADT. 9	Poonkar	June-September January-April	120	4,000	[illegible]	Medium	Do.
ADT. 16	Kona Kuruvai	....	115	3,600	..	Very fine	Do.
ADT. 18	Vellai Kuruvai	January-April	125	3,600	[illegible]	Medium	Do.
ADT. 19	Sarapalli	June-September	109	3,700	..	Do.	Dull white.
ADT. 20	Kuruvai	Do	105	4,200	1	Short round	White.
ADT. 22	Vadan Samba (NA)	July-January June-December	155	3,000	1	Medium	Brown.

Agricultural Research Station, Pattambi.

PTB. 1	Aryan	June-September	145	3,000	[illegible]	Medium	Red.
PTB. 2	Ponnaryan	Do.	135	2,500	2	Coarse	Do.
PTB. 4	Vellari	September-February	140	2,200	1	Do.	Do.
PTB. 7	Parambuvattan	June-September	125	2,800	1	Medium	Do.
PTB. 9	Veluthari thavala kannan	Do.	135	2,900	1	Do.	Do.
PTB. 10	Thekkanchera	June-September January-April	100	2,100	1	Do.	Do.
PTB. 11	Halliga	Do.	145	2,500	[illegible]	Do.	White.

APPENDIX LIX—*cont.*

Area under improved strains and their characteristics—cont.

RICE—*cont.*

Strain number.	Name.	Duration (seed to seed). Season.	Days.	Average acre yield in lb.	Area to which strain useful (in lakhs of acres).	Size of grain.	Colour of rice.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Agricultural Research Station, Pattambi—cont.					
PTB. 12	Chitteni	September-February	130	2,000	1	Medium.	Red.
PTB. 14	Mascathi	June-September	130	2,500	[illegible]	Do.	White.
PTB. 15	Kavinginpoothala (late)	September-February	165	3,000	[illegible]	Medium fine	Do.
PTB. 16	Do. (early)	July-January	155	2,800			
PTB. 18	Eravapandy	September-February	130	..	[illegible]	Medium	Do.
PTB. 19	Athikraya	Do.	145	..	[illegible]	Do.	Red.
PTB. 20	Vadakkan Chitteni	Do.	120	..	1	Medium coarse	Do.
PTB. 21	Thekkan	Do.	130	..	[illegible]	Medium	Do.
PTB. 23	Veluthavattan	June-September	120	..	[illegible]	Medium coarse	Do.
PTB. 24	Chuvannavattan	Do.	120	..	[illegible]	Do.	Do.
		Agricultural Research Station, Tirurkuppam.					
TKM. 1	Sornavari	June-September	..	..	..	....	....
		Agricultural Research Station, Anakapalle.					
AKP. 3	Gunupursannam	June-December	145	2,500	[illegible]	Medium	Light brown.
AKP. 4	Mypali	Do.	145	2,500	1	Coarse	White.
AKP. 5	Do.	Do.	150	2,900	[illegible]	Do.	Do.
AKP. 9	Bangaruthiga	Do.	150	2,700	1/8	Medium	Do.
AKP. 8	Maharaja Bhogam	June-December	150	2,500	1/8	Do.	Do.
AKP. 11	Ramasagram	....	145	3,200	1/8	Coarse	Do.
BAM. 3	Bayyahunda	....	..	3,000	2	Medium	Do.

Agricultural Research Station, Samalkota.

SLO. 1	Punasakonamani	June-December	190	3,100	1	Coarse	White.
SLO. 2	Do.	....	190	3,400	1	Medium	Do.
SLO. 9	Gorti Basangi	....	175	2,500	[illegible]	Do.	Do.
SLO. 12	Tella Garikasannavari	January-April	150	2,200	[illegible]	Do.	Do.
SLO. 13	Punasa Akkulu	June-December	190	4,100	1[illegible]	Do.	Do.
SLO. 15	Pedda Konamani	Do.	200	4,600	[illegible]	Coarse	Do.
SLO. 16	Kasi Pichodi	January-April	145	2,000	1/5	Medium fine	Do.
SLO. 17	Gutti Kichili	June-December	190	4,400	[illegible]	Medium	Do.

Agricultural Research Station, Buchireddipalem.

BCP. 1	Sanna Molugolukulu	July-January	..	2,500	..	....	White.
BCP. 2	Potti Molugolukulu	Do.	..	2,500	..	....	Do.

Agricultural Research Station, Ambasamudram.

ASD. 1	Kar samba (red)	June-September January-April	115	4,000	1	Medium coarse	Red.
ASD. 3	Veedhividangan	June-September	130	3,200	1/10	Coarse	Do.
ASD. 4	Kuruvaikalayan	July-January	135	2,400	[illegible]	Do.	Do.
ASD. 5	Karthigai samba	September-February July-January	135	3,500	2	Medium	White.
ASD. 6	Anaikomban	....	170	3,800	[illegible]	Medium fine	Do.
ASD. 7	Karsamba (red)	....	110	4,000	[illegible]	Coarse	Red.

APPENDIX LX.

Sorghum (Cholam).

Serial number. (1)	Strain number. (2)	Strain name. (3)	Regions. (4)	Approximate area in acres. (5)	Botanical name. (6)	Irrigated or rainfed. (7)	Season of sowing (8)	harvest. (8)	Duration in days. (9)	Yield per acre in lb. Grain. (10)	Yield per acre in lb. Straw. (11)
1	Co. 1 ..	Periamanjal cholam.	Coimbatore .., Salem .., Chingleput .., Tiruchirappalli .., Tanjore ..	50,000	Sorghum durra, var Coimbatoricum.	Rainfed	July-August.	December-January.	135	700 to 1,200	2,000 to 3,000
2	Co. 2 ..	Talaivirichan cholam.	Salem .., Coimbatore .., Chittoor .., North Arcot .., South Arcot ..	20,000	Sorghum Roxburghii var. hians.	Do.	Do.	Do.	145	800 to 1,200	1,400 to 2,000
3	Co. 3 ..	Do.	Salem .., Coimbatore .., Chittoor .., North Arcot .., South Arcot .., Chingleput ..	25,000	Do.	Do.	Do.	Do.	145	800 to 1,200	1,400 to 2,000
4	Co. 4 ..	Sen cholam ..	Salem .., Tiruchirappalli ..	20,000	Sorghum sub-glabrescens.	Irrigated.	February-March.	May-June.	90	2,000 to 2,500	4,000 to 5,000
5	Co. 5 ..	Chinnamanjal cholam.	Coimbatore ..	10,000	Do.	Do.	March.	June.	100	2,250 to 2,750	4,500 to 5,500
6	Co. 6 ..	Chitraivellai cholam.	Coimbatore ..	6,000	Do.	Do.	Do.	Do.	115	2,000 to 2,500	4,000 to 4,750
7	Co. 7 ..	Vellai cholam ..	Coimbatore .., Salem .., Madhurai .., Tiruchirappalli ..	20,000	Do.	Do.	Do.	Do.	110	2,500 to 3,000	5,000 to 6,000
8	Co. 8 ..	Kanaivellai cholam.	Coimbatore .., Tiruchirappalli ..	5,000	Do.	Do.	Do.	Do.	100	2,500 to 2,750	5,000 to 6,000
9	Co. 9 ..	Vellai cholam ..	Coimbatore .., Salem .., Ramanathapuram, Madhurai .., Tiruchirappalli .., Chittoor .., North Arcot .., South Arcot ..	100,000	Do.	Do.	Do.	Do.	95	2,500 to 2,750	5,000 to 6,000
10	Co. 10 ..	Mutant from Palna Jonna long duration.	Coimbatore .., Chingleput .., South Arcot .., Tiruchirappalli, Tanjore ..	10,000	Sorghum durra var mediocre.	Irrigated and dry.	March-June.	August-December.	100 (fodder) 150 (grain)	600 to 1,000	64,000 (green).
11	Co. 11 ..	Short duration Mutant.	Do.	25,000	Do.	Do.	March-August.	June-December.	75 (fodder) 100 (grain)	2,000 to 4,500	20,000 (green).

12	Co. 12 ..	Uppam or Mottai vellai cholam.	Tiruchirappalli .. Madhurai .. Ramanathapuram	5,000	Sorghum subglabrescens.	Irrigated.	January-March.	April-June.	85 90	2,500 to 3,000	4,000 to 5,000
13	Co. 13 ..	Ennai vellai cholam.	Coimbatore .. Tiruchirappalli ..	5,000	Do.	Do.	March.	June.	105	2,500 to 3,000	4,000 to 5,000
					Agricultural Research Station, Anakapalli.						
14	AKP. 1..	Patsa jonna ..	Visakhapatnam.	..	Sorghum durra, var mediocre.	Dry ..	May-August.	August-December.	110	1,600	5,000
15	AKP. 2..	Tella jonna	Do. ..	..	Sorghum Roxburghii var-hians.	Dry ..	Do.	Do.	120	1,100	6,000
16	AKP. 3..	Dandu jonna ..	Do. ..	..	Sorghum durra var mediocre.	Dry ..	Do.	Do.	110	1,150	8,000
					Agricultural Research Station, Guntur.						
17	G. 1 ..	Mudda jonna ..	Guntur .. Kurnool ..	50,000	Sorghum durra var mediocre.	Dry ..	September-October.	December-January.	120	1,000	2,250
18	G. 2 ..	Do. ..	Do.	50,000	Do.	Dry ..	Do.	Do.	120	1,200	2,700
19	G. 3 ..	Budda gidda jonna.	Do.	..	Do.	Irrigated.	June-July.	October-November.	90	1,500	3,200
20	G. 4 ..	Yerra jonna ..	Do.	..	Sorghum subglabrescens.	Do.	Do.	Do.	85	1,600	3,800
					Agricultural Research Station, Nandyal.						
21	N. 1 ..	Cheruku patcha jonna.	Cuddapah .. Kurnool ..	..	Sorghum durra var mediocre.	Dry ..	June-October.	November-January.	120	650	1,500
22	N. 2 ..	Gundupatsa jonna.	Do.	200,000	Do.	Dry ..	Do.	Do.	120	1,000	2,000
23	N. 3 ..	Patcha jonna	Do.		Do.	Dry ..	Do.	Do.	110	700	1,600
24	N. 4 ..	Ooia patcha jonna.	Do.		Do.	Dry ..	Do.	Do.	120	850	2,000
25	N. 5 ..	Patcha jonna ..	Do.		Do.	Dry ..	Do.	Do.	110	600	1,500
26	N. 6 ..	Do. ..	Do.		Do.	Dry ..	Do.	Do.	110-120	750	1,600
27	N. 7 ..	Do. ..	Do.		Do.	Dry ..	Do.	Do.	Do.	1,200	1,800
28	N. 8 ..	Do. ..	Do.		Do.	Dry ..	Do.	Do.	Do.	1,200	1,500
29	N. 9 ..	Do. ..	Do.		Do.	Dry ..	Do.	Do.	Do.	1,500	1,600
					Agricultural Research Station, Hegari.						
30	H. 1 ..	Tella jonna ..	Anantapur .. Bellary ..	300,000	Sorghum cernuum.	Dry ..	September-October.	January-February.	135	250	1,100
31	M. 47-3 ..	Maladandi jowar ..	Do.	15,000	Do.	Dry ..	Do.	Do.	120	320	1,000
					Agricultural Research Station, Koilpatti.						
32	K. 1 ..	Mattu cholam	Tinnevelly ..	10,000	Sorghum dochna.	Irrigated and dry.	January. September-October.	May. December-January.	120 to 135	100	3,000 (Dry fodder).
33	K. 2 ..	Irrigated vellai cholam.	Madhurai .. Ramanathapuram. Tirunelveli.	20,000	Sorghum subglabrescens.	Irrigated.	April.	July.	120 to 125	2,000 to 2,500	4,000 to 5,000

NOTE.—Co. 12 and Co. 13 are newly released. Co. 9 is very popular.

APPENDIX LXI.

Bajra (Cumbu).

Serial number. (1)	Strain number. (2)	Strain name. (3)	Regions. (4)	Approximate area in acres. (5)	Botanical name. (6)	Irrigated or rainfed. (7)	Season of sowing harvest. (8)		Duration in days. (9)	Yield per acre in lb. Grain. (10)	Straw. (11)
							Sowing	Harvest			
			Millet Breeding Station, Coimbatore.								
1	CO. 1 (P.T. 700)	Whip cumbu (Africa).	Guntur .. South Arcot .. Tiruchirappalli .. Ramanathapuram Salem .. Coimbatore. ..	25,000	Pennisetum typhoides Stapf and Hubb.	Dry and irrigated.	March-September-	June-January.	90	650 to 900 1,500 to 2,200	1,500 to 2,000 3,700 to 4,600
2	CO. 2 (P.T. 367).	Bajra (Bombay) ..	Madhurai .. Coimbatore ..	5,000	Do.	Dry ..	July-September.	October-December.	90	600 to 800	1,500 to 1,800
3	CO. 3 (P.T. 2229).	Kottapuli cumbu ..	South Arcot .. Tiruchirappalli .. Madhurai .. Ramanathapuram Salem .. Coimbatore ..	15,000	Do.	Irrigated.	April.	June.	85	1,600 to 2,000	4,000 to 4,500
4	Hybrids X 1 and 2.	....	Do.	..	..	..	..	..	..	1,000 to 3,000	5,000
			Agricultural Research Station, Anakapalle.								
5	AKP. 1	Rudraksha Ganti ..	South Visakhapatnam. North Visakhapatnam.	6,500	Pennisetum typhoides Stapf and Hubb.	Dry ..	May-June	August-September	90	1,450	3,000
6	AKP. 2	Pedda Ganti ..	Do.	6,500	Do.	Dry ..	Do.	Do.	95	1,550	4,000
7	AKP. 3	Poona Ganti ..	Do.	..	Do.	Dry ..	Do.	Do.	95	1,250	3,500
			Agricultural Research Station, Koilpatti.								
8	K. 1	Kattu cumbu	Madhurai .. Ramanathapuram Tirunelveli ..	100,000	Pennisetum typhoides Stapf and Hubb.	Dry and irrigated.	October. February.	January. May.	90	800 2,000	1,700 to 2,200 4,200 to 4,500
9	K. 2	Punjab cumbu	....	..	..	Do.	Do.	Do.	90	800	1,700 to 2,000 4,200 to 4,500

NOTE.— CO. 1—Sparse tillering.
CO. 2—Medium tillering.
CO. 3—Good tillering.

APPENDIX LXII.

Finger Millet (Ragi).

Serial number. (1)	Strain number. (2)	Strain name. (3)	Regions. (4)	Approximate area in acres. (5)	Botanical name. (6)	Irrigated or rainfed. (7)	Season of sowing harvest. (8)		Duration in days. (9)	Yield per acre in lb. Grain. (10)	Yield per acre in lb. Straw. (11)
							Sowing	Harvest			
			Millet Breeding Station, Coimbatore.								
1	CO. 1 (E.C. 593).	Gidda Aryam (Salem).	Guntur .. Nellore .. Chittoor .. Chingleput .. Salem .. .. North Arcot .. Madurai .. Coimbatore .. Malabar .. South Kanara ..	200,000	Eleusine coracana Geartn.	Irrigated and Rain fed.	May-June.	September-October.	120	2,200 to 2,500 2,500 to 700	5,000 to 6,000 2,000 to 2,250
2	CO. 2 (E.C. 3517).	Mutti ragi (Udamalpet).	Chingleput .. North Arcot .. Tiruchirappalli .. Madurai .. Ramnathapuram. Tirunelveli .. Coimbatore ..	30,000	Do.	Irrigated.	May-July.	Do.	110	2,000 to 2,200	4,000 to 4,500
3	CO. 3 (E.C. 3735).	Mutant from Gidda Aryam.	Chittoor .. South Aroct .. Coimbatore ..	25,000	Do.	Do.	May-December.	September-March.	110	2,000 to 2,200	5,500 to 6,000
4	CO. 4 (E.C. 24)	Palladam Ragi ..	Ramanathapuram.	1,000	Do.	Irrigated and Rain-fed.	August-October.	January-February.	130 140	2,250 800	5,000 to 5,5[illegible] 2,000 to 2,200
			Agricultural Research Station, Anakapalle.								
5	AKP 1 ..	Burade chodi ..	South Arcot .. South Visakha-patnam. ..	1,000	Eleusine coracana Geartn.	Irrigated.	May .. (Punasa or	August .. Early season).	90	2,450	3,000
6	AKP 2 ..	Do.	Do. ..	30,220	Do.	Do.	Do.	Do.	85	2,600	3,000
7	AKP 3 ..	Pyru chodi ..	North Visakha-patnam. ..	20,000	Do.	Do.	December -	April .. (Pyru or late season).	100	1,100	1,200
8	AKP 4	Do.	Do.	..	Do.	Do.	Do.		95	1,350	1,500
9	AKP 5	Do.	Do.	..	Do.	Do.	Do.		90	1,400	1,500

APPENDIX LXII—*cont.*

Finger Millet (*Ragi*)—cont.

Serial number. (1)	Strain number. (2)	Strain name. (3)	Regions. (4)	Approximate area in acres. (5)	Botanical name. (6)	Irrigated or rainfed. (7)	Season of sowing harvest. (8)		Duration in days. (9)	Yield per acre in lb. Grain. (10)	Straw. (11)
					Agricultural Research Station, Anakapalle—cont.						
10	AKP 6	Mottu Nalla chodi.	North Visakhapatnam.	10,000	Eleusine coracana Geartn.	Dry.	August-September. (Peddapanta or main season).	December.	100	1,350	2,500
11	AKP 7	Mottu Tella chodi	Do.	5,000	Do.	Dry.	Do.	Do.	105	1,350	3,000
					Agricultural Research Station, Hagari.						
12	H 1	Mutant from CO 1 Gidda Aryam Salem.	Kurnool .. Bellary .. Anantapur .. Cuddapah ..	10,000	Eleusine coracana Geartn.	Irrigated.	January-June.	May-November.	130	2,000 to 2,300	3,400 to 4,500
					Agricultural Research Station, Palur.						
13	R 382	Perum ragi (Palur).	South Arcot ..	3,000	Eleusine coracane Geartn.	Irrigated.	April-May.	September.	110	2,000	4,500
					Agricultural Research Station, Koilpatti.						
14	K 1	Koilpatti Ragi ..	Tirunelveli Ramanathapuram.	8,000	Eleusine coracana Geartn.	Irrigated.	July. September.	January-February.	110	2,000 to 2,300	5,000 to 5,500

APPENDIX LXIII.

Setaria (Tenai).

Serial number.	Strain number.	Strain name.	Regions.	Approximate area in areas.	Botanical name.	Irrigated or rainfed.	Season of sowing	harvest.	Duration in days.	Yield per acre in lb. Grain.	Straw.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		(9)	(10)	(11)
					Millet Breeding Station, Coimbatore.						
1	CO. 1 (S.I. 523).	Mosu tenai ..	South Arcot .. Coimbatore ..	1,000	Sataria italica.	Irrigated and dry.	March-September.	February. July December.	100	1,100, 750 to 850.	1,500 1,000 to 1,200.
2	CO. 2 (S.I. 544).	Sadai tenai	Do. ..	500	Do.	Irrigated.	March ..	July ..	90	1,000	1,500 to 1,700
3	CO. 3 (S.I. 3223).	Perum tenai	..	500	Do.	Dry ..	September.	December.	100	800 to 1,000	1,000 to 1,500
					Agricultural Research Station, Guntur.						
4	G 1	Punasa korra ..	Guntur ..	1,000	Sataria italica.	Dry.	June-September.	October-January.	90	1,500	2,200
					Agricultural Research Station, Nandyal.						
5	N 1	Chenna korra ..	Kurnool ..	10,000	Sataria italica.	Dry.	June-September.	September-December.	90	700	1,100
					Agricultural Research Station, Hagari.						
6	H 1	Korra Parama Devanahalli.	Bellary .. Anantapur .. Cuddapah ..	100,000	Sataria italica.	Dry.	July-September.	November-December.	110	200 to 350	400 to 500
7	H 2	Korra	Bellary Anantapur Cuddapah. ..	200,000	Do.	Dry.	Do.	Do.	100	300 to 350	500 to 600

NOTE.—Figures given in Column 5 are estimated areas.

APPENDIX LXIV.

Oilseed.	Strain number.	Habit.	Duration (months).	Season suitable for cropping.	Districts suitable for cultivation.	Average yield per acre. Rainfed crop.	Average yield per acre. Irrigated crop.	Chief attributes of the strains.	Estimated area under the improved strains.
(1)	(2)	(3)	(4)	(5)	(6)	(7)		(8)	(9)
					Groundnut.				
Groundnut (*Arachis hypogaea L*) *Tamil*—Verkadalai Nilakkadalai Manilakottai. *Telugu*.—Verusanaga *Kanarese*.—Nelakadale *Malayalam*.—Nilakkatala.	*TMV 1.* (AH 25).	spreading.	4½	*Rainfed*.—July-August to November-December. *Irrigated*.—February-March to June-July.	Almost all the districts of the State and more particularly the districts of Tiruchirapalli, Madurai, Ramanathapuram, Tirunelveli, Cuddapah and Anantapur.	1,500 lb. of well dried pods.	3,000 lb. of well dried pods.	Partially resistant to drought and tikka leaf-spot disease. Harvesting is easy and less costly. Seeds dormant. The kernels contain 50 per cent oil.	
	TMV 2. (AH 32).	Bunch or Erect.	3½	*Rainfed*.—July, August to October, November. *Irrigated*.—February, March to May-June.	North Arcot, Guntur Ramanathapuram, Tirunelveli, Tanjore and Krishna.	1,000 lb. of well dried pods.	3,000 lb. of well dried pods.	A short duration one suitable for early sowings in tracts where two crops are taken. Easily harvested. The kernels contain 49 per cent oil.	Total 4 lakhs of acres.
	TMV 3 (AH 698).	Spreading.	4½	*Rainfed*.—July-August to November-December.	Almost all the districts of the State, particularly in the districts of South Arcot, North Arcot, Chittoor and Salem.	1,500 lb. of well dried pods.	..	High shelling percentage (77 per cent). Eminently suited for sowing in drills. The kernels contain 50 per cent oil.	
	AH 334.	Spreading.	4½	Irrigated or summer February-March to June-July.	South Arcot, Salem, Tiruchirapalli and Madurai.	..	3,500 lb. of well dried pods.	Gives high yield in summer under irrigated conditions and has large number of three seed pods. The kernels contain 50 per cent oil.	

Gingelly.

Gingelly .. (*Sesamum orientale*). *Tamil*— Ellu. *Telugu*— Nuvvulu. *Kanarese*— Yellu. *Malayalam*— Ellu.	TMV. 1. / (SI 89)	..	85 days.	*Rainfed.*—October-November to January—February. *Irrigated.*—February-March to May-June.	South Arcot, North Arcot, Chittoor, Chingleput, Salem, Coimbatore, Malabar, Tiruchirappalli, Madurai, Tanjore, Ramanathapuram and Tirunelveli.	200 to 300 lb.	500 lb.	A high yielding strain for rainfed and summer seasons. Seeds contain 50 per cent oil.	80,000 acres
	TMV. 2. / (X 6.)	..	80 days.	*Rainfed.*—Cold weather December-March.	The strain is under district trials. It has been found suitable for South Arcot, North Arcot, Nellore, Tanjore and portions of Kurnool.	250 to 350 lb.	..	A high yielding strain containing 2 per cent more oil than the local. The seeds contain 52 per cent oil.	
	TMV. 3. / (X 38)	..	80 days.	*Irrigated.* Summer February-March to May-June.	The strain is under district trials. It has been found suitable so far for South Arcot, Tanjore, Coimbatore and Nellore districts.	..	500 lb.	A high yielding strain for summer cropping. Shorter in duration, contains 2 per cent more oil than the local. Fairly resistant to wilt and shoot webber attack. The seeds contain 52 per cent oil.	

Castor.

Castor .. .. (*Ricinus Communis*). *Tamil*— Kottamuthu. *Telugu*— Amudalu. *Kanarese*— Haralu. *Malayalam*— Aavanakku.	TMV. 1. / (RC. 59-8-1)	..	6½	*Rainfed.*- May-June to December-January.	Anantapur, Bellary, Kurnool and Guntur.	600 to 800 lb. of beans for a pure crop.	..	A high yielding short duration strain. The beans contain 51 per cent oil.	4,000 acres.
	TMV. 2. / (RC. 59-2-1-1)	..	7	*Rainfed.*—May-June to January-February.	Salem, Coimbatore, South Arcot, and North Arcot.	600 to 800 lb. of beans for a pure crop.	..	A high yielding medium duration strain. Capsules non-dehiscent and without shedding seeds. The seeds contain 50 per cent oil.	

APPENDIX LXIV—*cont.*

Oilseed.	Strain number.	Habit.	Duration (months).	Season suitable for cropping.	Districts suitable for cultivation.	Average yield per acre. Rainfed crop.	Average yield per acre. Irrigated crop.	Chief attributes of the strains.	Estimated area under the improved strains.
(1)	(2)	(3)	(4)	(5)	(6)	(7)		(8)	(9)
					Castor—cont.				
Castor (*Ricinus Communis*) —cont. ..	TMV 3. (R.C. 215)	..	8	*Rainfed.*—May-June to January-February. *Irrigated.*—At all times as a border for garden land crops.	As a rainfed crop in Nellore district and as a border for garden land crops like Sugarcane, turmeric, chillies, etc., in all the districts where such crops are generally raised.	600 to 800 lb. of beans for a pure crop.	..	A high yielding long duration strain with high oil content. The beans contain 55 per cent oil.	4,000 acres—*cont.*
	CO. 1.	..	A perennial type.	Can be grown both under rainfed and irrigated conditions.	At higher elevations in Nilgiris and Malabar districts.	2 to 3 lb. per plant per year.	..	A high yielding perennial type suited for growing as a shade crop in plantations and also waste lands. The seeds contain 55 per cent oil.	
					Cocoanut.				
Coconut (*Cocos nucifera*).	Selected coconut seedlings of the tall variety and seedlings of Tall X Dwarf cross.	..	Perennial tree living up to an age of over 80 years.	Planting of seedlings is generally done at the break of the monsoon rains.	All the districts of the State where climate and soil conditions are suitable for the cultivation of coconut.	60 to 80 seedlings per acre.	At full bearing stage the trees will yield on an average 80 to 100 nuts per tree per annum.	The tree is hardy and long lived. Nuts, copra, oil and fibre of good quality. It is early and prolific bearer with the good nut and copra characters.	Seedlings sufficient to plant 2,500 acres have so far been distributed.

APPENDIX LXV.

Cotton.

Serial number. (1)	Name of recommended strain and botanical species. (2)	Regions of growth. (3)	Seasons. Planting. (4)	Seasons. Harvesting. (5)	Seed rate for one acre. (6)	Approximate area during (acres) 1948–49. (7)	Yield of lint per acre. (8)	Particulars of lint characters. Staple length in inches. (9)	Particulars of lint characters. Ginning percentage. (10)	Particulars of lint characters. Spinning value. HS. WC. (11)	Estimated area of commercial varieties as per trade classification (average of five years ending 1948–49.) (12)	Estimated production of commercial variety in bales of 400 lb. lint (average of five years). (13)	Resistance to pest and diseases. (14)
						American Cottons.							
1	Cambodia-2 (*Gossypium hirsutum*).	Coimbatore, Salem, Tiruchirapalli, Madurai, Ramanathapuram and Tirunelveli.	Sep. to Oct.	Jan. to Mar.	12 to 25 lb.	116,145	*Irrigated*—250 to 300 lb. *Rainfed*—100 to 125 lb.	28/32 to 31/32	34	37's	Cambodia.	*Irrigated*— 172,839 109,480 *Rainfed*— 132,774 35,343	Jassid.
2	Cambodia-3 (*Gossypium hirsutum*).	Salem ..	Do.	Do.	Do.	13,140	*Irrigated*—225 to 275 lb. *Rainfed*—100 to 125 lb.	1" to 1-1/16"	37	44's			Do.
3	Uganda-1 (*Gossypium hirsutum*).	Madurai, Ramanathapuram Tirunelveli, South Arcot, Coimbatore and Salem.	Feb. to Mar. Jan.- Sep. to Oct.	July to Sep. Sep.-Jan. to Mar.	Do.	33,028	*Irrigated*—250 to 300 lb. *Rainfed*—100 to 125 lbs.	Do.	37	44's			Jassid and blackarm.
4	X 4463 (*Gossypium hirsutum*).	Coimbatore and Tiruchirappalli.	Sep. to Oct.	Jan. to Mar.	Do.	5,000	*Irrigated*—250 to 300 lb.	1"	35	41's			Jassid.
						Desi Cottons.							
1	Karunganni-2 (*Gossypium arboreum*).	Madurai, Ramanadhapuram and Tirunelveli.	Oct. to Nov.	Feb. to Apr.	12 to 16 lb.	12,242	*Rainfed*— 110 to 130 lb.	28/32 to 30/32	32	29's	Tinnies.— 490,484	84,349	
2	Karunganni-5 (*G. arboreum*).	Coimbatore, Tiruchirapalli and parts of Madurai.	Do.	Do.	Do.	44 133	*Rainfed*— 100 to 125 lbs.	28/32 to 30/32	30	30's			

APPENDIX LXV—*cont.*

Cotton—cont.

Serial number. (1)	Name of recommended strain and botanical species. (2)	Regions of growth. (3)	Seasons. Planting. (4)	Seasons. Harvesting. (5)	Seed rate for one acre. (6)	Approximate area (acres) during 1948–49. (7)	Yield of lint per acre. (8)	Particulars of lint characters. Staple length in inches. (9)	Particulars of lint characters. Ginning percentage. (10)	Particulars of lint characters. Spinning value. HS. WC. (11)	Estimated area of commercial varieties as per trade classification (average of five years ending 1948–49). (12)	Estimated production of commercial variety in bales of 400 lb. lint (average of five years). (13)	Resistance to pest and diseases. (14)
						Desi Cottons—cont.							
3	Westerns-1 (*G. herbaceum*).	Bellary, Anantapur, Cuddapah and Kurnool.	Aug. to Sep.	Feb. to Apr.	10 to 12 lb.	385,581	*Rainfed*—50 to 60 lb.	26/32 to 28/32.	28	26's	Westerns—563,554	60,435	..
4	Northerns-14 (*G. herbaceum*).	Kurnool ..	Do.	Do.	Do.	18,600	Do.	28/32 to 30/32.	24	40's	Northerns (red and white)—81,346	9,080	..
5	Cocanadas-1 (*G. arboreum*).	Godavari, Guntur and Nellore.	July to Sep.	Jan. to March.	Do.	1,000	*Rainfed*—70 to 80 lb.	28/32 (coloured cotton)	28	30's	Cocanadas and Warrangal—77,249	13,018	..
6	381-F (*G. arboreum*.)	Bellary, Kurnool, Visakhapatnam and Godavari, (for Mungari and Chinnapathi area).	June to July. July to Sep.	Jan. to Feb. Jan. to Mar.	"	Proposed to be multiplied.	Do.	28/32	31	27's	Mungari 32,000 Chinnapathi—3,580	3,350 400	..

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